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PSYCHE

VOL. XXXI. APRIL 1924 No. 2

A NEW SPECIES OF SCHIZASPIDIA (EUCHARIDÆ), WITH NOTES ON A EULOPHID ANT PARASITE.[1]

By George C. Wheeler and Esther Hall Wheeler.

Schizaspidia polyrhachicida new species

(Fig. 1.)

Female. Head small, three times as broad as long in dorsal view; but little narrower than the width of the thorax. Ocelli almost in a straight line, the outer ones less than an ocellus-diameter behind, the central one sunk in a grove which includes the antennal insertions. Head nearly twice wider than deep. Distance from ocellus to clypeus five-sevenths that from eye to eye. Malar line about equal to base of clypeus. Upper two-thirds of face striated vertically; those striæ nearest the antennal groove curved medially and continuous with transverse striæ below antennæ and also behind ocelli; those nearest the eyes continuous with transverse striæ on the vertex. Lower third of face smooth. Transverse striæ arising at either side of clypeus and passing backward across the genæ and then upward behind the eye. Clypeus smooth. Antennæ twelve-segmented, extending nearly to the metascutellum; first segment one-half, and second segment one-third the length of the third, which is one-third as wide as long; fourth three-fourths of third; remaining segments of equal length, about one-half of third. Labrum with eight digitiform processes on its anterior border. Mandibles long, falciform; the right one with two teeth at the inner base, the left with one larger tooth.

Thorax as long as wide dorsally, coarsely reticulate-rugose.

[1]Contribution from the Zoological Department in the Liberal Arts College, Syracuse University.

Prothorax extremely suppressed. Scutellar protuberance short, one-third the length of the scutellum, terminating in two short, asymmetrical prongs separated by a distance greater than their length. A wide reticulate-rugose channel extending from the base of the protuberance to the anterior border of the metascu-

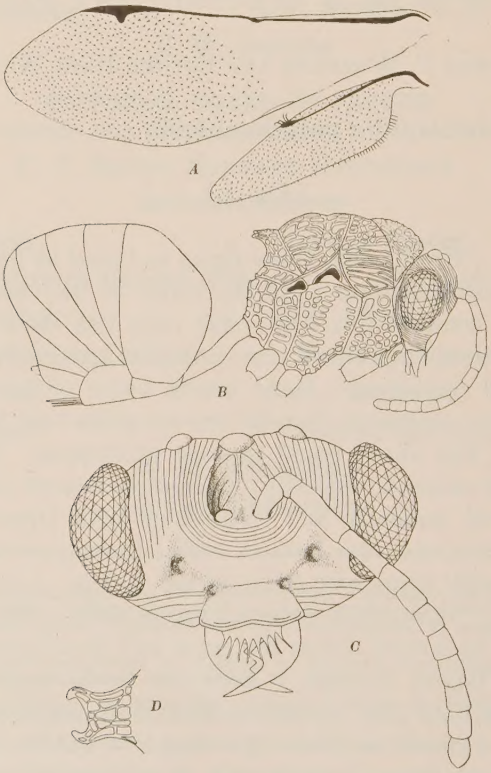

Fig. 1. *Schizaspidia polyrhachicida* n. sp. ♀. A, wings; B, lateral view; C, head in front view; D, metascutellar protuberance in dorsal view.

tum, where it is dilated into a deep pit surrounded by a ridge. Wings hyaline, reaching a little beyond the apex of the abdomen. Apical three-fifths of fore wing and entire hind wing finely hairy.

Hind wing with vein extending to hooks, which are four in number, and with a fringe of cilia on the posterior border. Tibial spurs simple.

Gaster nearly twice as long as broad dorsally. Petiole less than one-half the length of the gaster, almost as long as the hind femur (13:14), and extending from the base of the propodeum to the lower margin of the gaster. First gastric segment partly inclosing the two following segments. Ovipositor without barbs, exposed for one sixth of the length of the gaster.

Head and thorax aëneous, except antennæ and mandibles which are fulvous with fuscous inner borders. Legs fulvous, except dark brown metacoxæ. Abdomen dark brown with these exceptions: dorsal spot on pedicel and most of first segment of gaster fuscous, rest of pedicel fulvous.

Length: 3.5 mm. *Host.—Polyrhachis* (*Myrmhopla*) *dives* F. Smith.

Type Locality.—Manila, Philippine Islands. Described from two mature female pupæ found in cocoons of the host collected by McGregor. The ants are from Professor W. M. Wheeler's collection.

This species is near *S. tenuicornis* Ashmead, but is readily distinguishable from it by the pit on the metanotum. Mr. A. B. Gahan has very kindly compared a specimen with Ashmead's types in the United States National Museum.

The head of the parasitic pupa was at the anterior pole of the host cocoon, and its brilliant vermilion eyes were readily visible through the silken walls of the latter. The host pupa (phthisergate) had been almost completely drained of its contents, scarcely more than the exoskeleton remaining; this was pressed against the venter of the parasite.

This is the fourteenth species of *Schizaspidia* to be described, but only the third host record.[2] Mr. Curtis P. Clausen (1923) has recently shown what an interesting field of investigation the biology of this widely distributed genus affords. All the Eucharidæ, for that matter, probably have the same possibilities.

[2] *S. doddi* Bingham.—*Camponotus* sp. (Dodd, 1906).
S. ternucornis Ashmead.—*Camponotus herculeanus japonicus* May (Clausen, 1923).

So far as is known, they parasitize ants exclusively. We have been able to find host records for twenty-one species in thirteen genera. The life histories of *Orasema viridis* Ashmead (Wheeler, 1907), *Psilogaster fasciiventris* Brues (1919), and *Schizaspidia tenuicornis* Ashmead (Clausen, 1923) are known. All three have planidium larvæ in the first stage.

Catalogue of the Genus Schizaspidia Westwood.

caeruleiceps Cameron. ♂. Borneo: Kuching.

Schizaspidia cæruleiceps Cameron, Entomologist, vol. 42, p. 231 (1909).

caffra Westwood. ♂? Africa: Caffraria.

Schizaspidia caffra Westwood, Thesaur. Entom. Oxon., p. 152; plate 28, fig. 12 (1874). Dalla Torre, Cat. Hym., vol. 5, p. 363 (1898). Schmiedeknecht, Gen. Insect., fasc. 97, p. 76 (1909).

cyanea Walker. ♂. Moluccas: Amboina.

Schizaspidia cyanea Walker, Trans. Entom. Soc. London (3) vol. 1, p. 386 (1862). Dalla Torre, Cat. Hym. vol. 5, p. 363 (1898). Schmiedeknecht, Gen. Insect., fasc. 97, p. 76 (1909).

doddi Bingham. ♂. Queensland: Townsville.

Schizaspidia doddi Dodd, Trans. Entom. Soc. London, p. 123 (1906). Girault, Mem. Queensland Mus., vol. 4, p. 235 (1915).

furcifera Westwood. ♂? ♀? Asia: Eastern India and Bengal.

Schizaspidia furcifer Westwood, Proc. Zool. Soc. London, vol. 3, p. 69 (1835).

Schizaspidia furcifera Westwood, Thesaur. Entom. Oxon., p. 151, plate 28, fig. 2 (1874). Kirby, Journ. Linn. Soc. London, Zool., vol. 20, p. 31 (1886). Dalla Torre, Cat. Hym., vol. 5, p. 364 (1898). Schmiedeknecht, Gen. Insect, fasc. 97, p. 76 (1909).

maculata Westwood. ♀. Brazil; Central Goyaz.

Schizaspidia (?) *maculata* Westwood, Thesaur. Entom. Oxon., p. 153, plate 28, fig. 1 (1874).

Orasema maculata Kirby, Journ. Linn. Soc. London, Zool., vol. 20, p. 29, plate 1, fig. 1 (1886). Dalla Torre, Cat. Hym., vol. 5, p. 361 (1898). Ashmead, Mem. Carnegie Mus., vol. 1, p. 469 (1904).

Schizaspidia maculata Schmiedeknecht, Gen. Insect., fasc. 97, p. 76, (1909).

murrayi Kirby. ♂. Tonga Islands: Tongatabu.

Schizaspidia murrayi Kirby, Ann. & Mag. Nat. Hist., (5) vol. 13, p. 403 (1884). Kirby, Journ. Linn. Soc. London, Zool., vol. 20, p. 37, (1886). Dalla Torre, Cat. Hym. Vol. 5, 364 (1898). Schmiedeknecht, Gen. Insect., fasc. 97, p. 76 (1909). Girault, Mem. Queensland Mus., vol. 4, p. 235 (1915).

polyrhachicida G. Wheeler & E. Wheeler. ♀. Philippine Islands: Manila.

Schizaspidia polyrhachicida G. Wheeler & E. Wheeler, Psyche, vol. 31, p. 49.

pretendens Walker. ♂. Brazil: Villa Nova.

Schizaspidia pretendens Walker, Trans. Entom. Soc. London, (3) vol. 1, p. 385 (1862). Dalla Torre, Cat. Hym., vol. 5, p. 364 (1898). Ashmead, Mem. Carnegie Mus., vol. 1, p. 469 (1904). Schiemdeknecht, Gen. Insect., fasc. 97, p. 76 (1909).

quinqueguttata Girault. ♂. Queensland: Gordonville (Cairns).

Schizaspidia quinqueguttata Girault, Mem. Queensland Mus., vol. 4, p. 235 (1915).

rudis Westwood. sex? South Australia: Angas.

Schizaspidia rudis Westwood, Thesaur. Entom. Oxon., p. 152, plate 28, fig. 5 (1874). Dalla Torre, Cat. Hym., vol. 5, p. 364 (1898). Schmiedeknecht, Gen. Insect., fasc. 97, p. 76 (1909). Girault, Mem. Queensland Mus., vol. 4, p. 235 (1915).

septentrionalis Brues. ♀. Arizona: Huachuca Mts.

Schizaspidia septentrionalis Brues, Bull. Wisconsin Nat. Hist. Soc., vol. 5, p. 104 (1907).

tenuicornis Ashmead. ♀ ♂. Japan: Northern Hondo and Hokkaido. Korea.

Schizaspidia tenuicornis Ashmeàd, Journ. New York Entom. Soc., vol. 12, p. 151 (1904). Clausen, Ann. Entom. Soc. America, vol. 16, p. 195-215 (1923).

trimaculata Cameron. ♀. Borneo: Kuching.

Schizaspidia trimaculata Cameron, Deutsch. Entom. Zeitschr., p. 205, (1909).

A EULOPHID ANT PARASITE

While examining a vial of ants (*Crematogaster acuta* Fabr.) collected by Professor W. M. Wheeler at Kartabo, British Guiana in the summer of 1920, we found that twenty-six of the larvæ were parasitized. In one instance, the parasites were pigmented pupæ, not, however, mature enough for identification. They were sent to Mr. A. B. Gahan, who reported as follows: "This is an Eulophid, apparently closely related to the genus *Paracrias* Ashmead, but I cannot identify it positively, even generically."

Of these twenth-six larvæ, twelve contained one parasite, thirteen contained two, while one contained four—a total of forty-one parasites, of which nineteen were larvæ and twenty-two were pupæ. Eleven host larvæ contained pupal parasites sufficiently developed for the sex to be evident: four contained one parasite (female); seven contained two—a male and a female in every case. With two parasites in one host, the heads of the former were at the caudal and of the latter. Of the four containing only one parasitic pupa, two had the heads directed towards the anterior end and two towards the posterior end of the host.

Figure 2 shows the mature pupæ referred to above—a male (length 2.0 mm.) on the right and a female (length 2.4 mm.)—with their ventral surfaces contiguous and occupying the greater part of the host's interior. The cloudy mass posterior to the pupæ is apparently a residue of host tissues, but probably also contains the meconia of the parasites.

The Eulophid larvæ are elongate, cylindrical, and entirely destitute of hairs. The button-like head is small, subterminal and elliptical in oral view. The conspicuous mandibles are falciform and sharp-pointed.

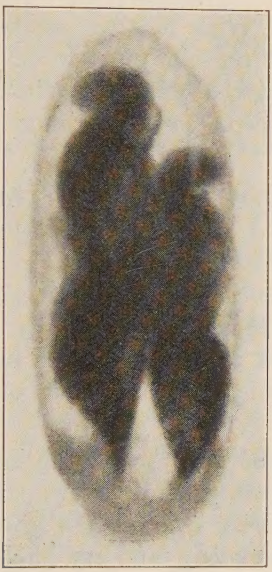

Fig. 2. Pupae of Eulophid parasite in larva of *Crematogaster acuta* Fabr.

This is, so far as we know, the only record of a Eulophid with an ant host. Although it cannot be stated definitely that the Eulophid is a primary parasite of the ant, it would seem that such is probably the case as none of the ant larvæ showed signs of parasitism by any other species.

Among the Chalcidoidea it is not unusual to find several parasites developing in a single host. In the Chalcididæ and Proctotrypidæ, where polyembryony occurs the number may reach a hundred, perhaps more. But this is not a case of polyembryony, for here both sexes occur within the same host individual. Whether all the parasites in a host larva are offspring of the same mother or whether two or more females have oviposited in one host (epiparasitism of Haviland) cannot, of course, be determined from our material. Among the Eucharidæ there are three records of this multiple parasitism:

Pseudochalcura gibbosa Provancher. (Host-*Camponotus herculeanus ligniperdus* var. *noveboracensis* Fitch.) "In one of the

cocoons,....., there were two pigmented and therefore nearly mature pupæ, lying face to face near the anterior pole while the remains of the ant pupa which they had consumed, were crowded against the black meconial spot at the posterior pole. The other cocoon contained four unpigmented pupæ." (Wheeler, 1907).

Rhipipallus affinis Bingham. (Host-*Odontomachus ruficeps coriaria* Mayr.)".....sometimes several from one cocoon." (Dodd, 1906).

Schizaspidia tenuicornis Ashmead. (Host-*Camponotus herculeanus japonicus* Mayr) "Occasionally two larvæ may be found on a single host pupa, and in such instances their position is symmetrical with reference to the body of the host." (Clausen 1923).

In all three of the above cases the host pupa is large and could easily provide nutriment for two, three or perhaps four parasites. But this is not true of the *Crematogsater* larvæ, which are only 2.8 millimeters long, and one might wonder whether on this ant multiple parasitism is generally successful.

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1923. Clausen, C. P. Ann. Entom. Soc. America, vol. 16, pp. 195-217.

1906. Dodd, F. P. Trans. Entom. Soc. London, pp. 119-132

1907. Wheeler, W. M. Bull. American Mus. Nat. Hist., vol. 23, pp. 1-93.

THE BIOLOGY OF *TRICHOPODA PENNIPES* FAB. (DIPTERA, TACHINIDÆ), A PARASITE OF THE COMMON SQUASH BUG.*

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PART II.

MORPHOLOGY

In the study of the adult anatomy, pinned dried specimens were used. For the definition of the mouth parts, sclerites of the thorax, and the genitalia, however, it was found necessary to relax the parts and examine them in liquid. For this purpose, specimens were soaked for about an hour in a cold 10 per cent solution of caustic potash (boiling often causes distortion of the parts) washed in water and treated with weak acetic acid to stop the action of the caustic potash. They were then placed in 70 per cent alcohol.

The parts were examined under a Zeiss binocular microscope, at magnifications varying from sixteen to sixty-five diameters. Many structures were obscure except under the brightest illumination, and therefore most of the examinations were made in the rays from a powerful lamp. A Ford headlight was mounted on a ringstand and connected through a transformer with the ordinary one hundred and ten volt circuit. This lamp proved to be quite satisfactory, since it was placed on the desk at a distance of two feet from the binocular, allowing plenty of room to work. A lamp of this kind, focussed upon the microscope stage by means of the set-screw in the lamp, throws little light into the eyes and develops little heat, while the object under observation is brought into strong relief.

*The first portion of this article appeared in Psyche, vol. 31, pp. 7-16, February, 1924.

Adult.

The adult fly is about the size of the common house fly but it is much more gay in appearance. It may be seen on sunny days hovering about squash plants, or resting with half-spread wings upon the foliage of squash and upon certain wild flowers as well. It is strikingly colored, with deep reddish brown eyes on a head marked with black, gold and silver. The thorax is golden in front, with four longitudinal black stripes, clear black behind, and gray at the sides. The abdomen is of a brilliant orange color, except at the extreme tip, which is darker. The conspicuous abdomen, and the fringe of feather-like setæ along the outer side of the hind tibiæ, immediately catch the eye of the observer, and serve to make this species one of the most striking among Tachinid flies.

A discussion of the adult anatomy is complicated by the diversity of terms which may be applied to the different structures. Taxonomists have applied names which, in many cases, are morphologically inaccurate, and morphologists themselves have differed both in the nomenclature and in the interpretation of parts. The source of the terms used in this paper is indicated in the text of the different sections, and in many cases duplicate names for the various structures are given in the list of abbreviations used in the figures.

Head. Pl. 1, figs. 1 and 2. In describing the head, the terms used are those of Peterson (1916), except the chætotaxy, which follows Coquillet (1897) and Walton (1909).

Viewed from in front, the head is elliptical in outline, and broader than deep (3.2 mm. by 2.4 mm.). Its most conspicuous feature is perhaps the frontal suture (fs),[2] which extends in a dark, shining, inverted U-shaped band from just above the insertion of the antennæ to a point midway between the vibrissæ (vib) and the curve of the compound eyes (ce), where it tapers out. Within the curve of the frontal suture lies the frontoclypeus (fc), termed by Coquillett the "facial depression" and

[2]Letters in parenthesis are those used in labeling the figures, and are explained in the list of abbreviations preceding the plates at the end of this paper.

by Walton the "facial plate." The tentorial thickenings (tt) arising at each side near the oral margin and running upward nearly to the insertion of the antennæ, are easily seen, lying just within the facial or vibrissal ridges, which are not pronounced. The vertex (v) is all that portion of the head, viewed is the ocellar triangle, bearing on its raised surface three ocelli (oc). From the region of the ocelli to the frontal suture runs a median broad velvety-black band or "vitta" (mv), which is demarked from the rest of the vertex only by its color, which strongly contrasts with the golden-yellow tomentum of the lateral portions of the vertex. The genæ (ge) are those portions of the vertex lying below the ends of the frontal suture, and between the oral margin and the eyes. Their color is silvery-gray, which shades into the gold of the rest of the vertex above, and into the brownish-yellow of the fronto-clypeus.

Viewed from the side the head is quadrate in shape. The postgenæ (pge) are those regions behind the genæ and extending backward and upward along the curve of the compound eyes to a point midway between the oral margin and the ocellar triangle. The occiput is designated as that portion of the caudal aspect of the head extending from a line drawn midway across the occipital foramen upward to the vertex. The edge of this area can be seen from the side (ocp).

Chætotaxy of the Head. On either side of the median vitta is a row of frontal bristles (fb) which, since they bend inward across the vitta, may be called "transfrontals."[1]

On the ocellar triangle, just behind the anterior ocellus, lie the great ocellar pair (ob), while behind these, and passing between the two lateral ocelli, follow three or more pairs of "lesser ocellar" bristles, which in *T. pennipes* are very small.

[1]Here is one instance of the confusion of terms mentioned at the beginning of this paper. The area bearing the frontal bristles, although it has been called the "front" by taxonomists, is morphologically not the front at all, but the vertex. The true front, which lies below the antennae and is fused with the clypeus, also bears a double row of macrochaetae which, to one not a specialist, might readily be mistaken for the frontal bristles. The writer does not recommend here any reconciliation between the terms of the morphologists and the usage of the taxonomists, but merely wishes to point out the true relation of parts. To his mind, any attempt to modify the terminology other than by concerted action among taxonomic workers and morphologists would only result in "confusion worse confounded."

Behind the ocelli and on the edge of the occiput is a transverse row of four macrochætæ. The inner, larger pair are the post-vertical bristles (pvt), and the smaller, outer ones, the inner vertical bristles (ivt). The outer verticals, present in some forms, are not represented in this species. The fronto-orbitals, which lie between the frontal bristles and the curve of the compound eyes, are also absent.

On the fronto-clypeus, disposed along each facial ridge, is a short row of facial bristles, the vibrissal row. The uppermost pair are the vibrissæ (vib) which in *T. pennipes* do not assume from the front, which lies between the compound eyes, and between these and the frontal suture. At the very top of the vertex their typical position immediately above the oral mragin, but are shifted upward to lie halfway between the oral margin and the tips of the antennæ. The smaller bristles accompanying the vibrissæ extend on either side in a single line along the oral margin to the region of the postgenæ, where they mingle with the silvery-white beard which depends from this region. A single row of short macrochætæ extends around the edge of the occiput from the inner vertical bristles downward to the region of the postgenæ. These are called the cilia of the posterior orbit (cpo).

Appendages of the Head.

Antennæ. The antennæ (ant) reach halfway between the base of the frontal suture and the oral margin. The first two segments are velvety-black in color, with a silvery sheen. The second segment bears a few macrochætæ. The third segment, which is much larger than the other two, is bean-shaped and varies from black to mouse-colored, with the base sometimes slightly tawny. This segment bears the arista (ar), a large bristle which is inserted on the outer edge about one third the distance from base to tip of the segment. The arista is practically bare, having but a few very tiny hairs near its base.

Proboscis. The proboscis (pb), usually folded well back in the oral cavity, is a very much modified structure, the parts of which it is very difficult to homologize with the mouth parts of

generalized insects. The work of Peterson (1916) on the mouth parts of Diptera was very thorough, and his figures correct and intelligible, but since he derives his hypothetical dipterous mouth parts from a consideration of Orthoptera while Crampton (1921, p. 91) would evolve Diptera from ancestors like Mecoptera, the homologies of dipterous mouth parts still constitute a disputed question.

The membrane of the basiproboscis (bpb) is largely composed of the mentum and sub-mentum, according to Peterson. The maxillary palpi; (mxp) lie on this membrane in front. Above the maxillary palpi lie the exposed portions of the tormæ (to), and below lie the external plates of the stipes (st). The galeæ (ga) lie on the surface, and are continuous with the lower ends of the ental portions of the stipes. The large chitinous internal structure of the basiproboscis is the fulcrum (ful) and is composed of the basipharnyx, or united portions of the epipharynx and hypopharynx, and the ental portions of the tormæ. At the distal end of the basipharynx lies the hyoid (hy), which articulates with the distal portion of the hypopharynx as well, and through which passes the alimentary canal.

The mediproboscis (mpb) bears the chitinized plate, the theca (the), on its caudal aspect, and the hypopharynx (hyp) and labrum-epipharynx (lep) lie in a chitinized groove on the upper surface of the labium.

The distiproboscis (dpb) is composed of a pair of lobes or labella, which Peterson interprets as the paraglossæ (pg). Crampton, however, calls them the united labial palpi. Various other structures can be seen in the distiproboscis, such as a Y-shaped plate called the furca (fu) and the structures called pseudotrachæ (pst).

Thorax. Pl. I, figs. 3 and 4. The structure of the thorax in *Trichopoda pennipes* is typical of the order Diptera as a whole, in which the mesothorax, which is the only wing-bearing segment, is greatly enlarged and distorted, evidently for the purpose of accomodating the great wing muscles. The prothorax (P) is very small, and the metathorax, which bears the halteres(ha), is very much reduced.

In naming the sclerites of the thorax the terminology used by Young (1921), which is largely based on Crampton (1914), is employed.

The dorsal aspect of the thorax is completely covered by the notum of the mesothorax, as defined by Snodgrass (1909a), or the mesonotum. This is divided by two transverse sutures into three sclerites, the prescutum (psc^2), scutum (sc^2) and scutellum (sl^2). The prescutum, including the humeral calli (hc) is yellow in color, with four longitudinal bands of velvety-black. In the males the yellow coloration extends backward onto the scutum where it merges with the black of that sclerite. The scutellum of both sexes appears black to the naked eye, but under the binocular most specimens show a faint tinge of very dark orange. The scutum is produced laterally into an anterior wing process, the suralare (sur), and a posterior wing process, the adanale (ad). The scutellar bridge of Walton (sb) is seen as a lateral overlapping of the scutellum onto the scutum. Below this is the axillary cord (axc) of Snodgrass (1909a), which is produced to form the margin of the calypteres. A posttergite (pt^2) is demarked behind the scutellum. The pseudonotum or postnotum of Snodgrass, which he would recommend calling the "postscutellum", in this case is located ventrad of the scutellum, and cannot be seen from above. It is divided into a median plate, the meditergite (mt^2), and two pairs of lateral plates, the anapleurotergites ($aplt^2$) and the katapleurotergites ($kplt^2$). Mention may logically be made here of the character recently reported by Malloch (1923) for differentiating muscoid flies. In Malloch's own words, "It is invariably possible to distinguish between the Sarcophagidæ, Muscidæ and Calliphoridæ on one hand, and the Tachinidæ and Dexiidæ on the other, by the shape of the metanotum. In the last two this is biconvex in profile, there being a small but distinct convexity just below the scutellum which is absent in the other three families known to me." The use of the term "metanotum" by Malloch follows the usage of older taxonomic workers, and is morphologically inaccurate. It is really the meditergite (mt^2) of the postscutellum which is meant, and the "biconvexity"

apparent in Tachinidæ and Dexiidæ is conditioned by the presence of the posttergite (pt^2), which, as a glance at the figure will show, lies just below the scutellum. An examination of figures 38, 39, 40 and 41 of Young bears out this point.

The pleural region of the mesothorax is pollinose gray in color, and is much distorted. The pleural suture, which in generalized insects runs a nearly straight course from the coxal cavity to the wing base, thus dividing the pleuron into an anterior episternum and a posterior epimeron, is here bent twice at right angles, so that while the two ends are nearly vertical, the middle is horizontal. In addition a portion of the anepisternum (aes^2) has been split off from the rest by a secondary invasion of membrane, and has become closely associated with the anepimeron or pteropleurite ($ptp.^2$) The katepisternum has fused with the sternum to form the sternopleurite (stp^2). It is the enlargement of this sclerite which has evidently caused the bending of the pleural suture, and has crowded the meropleurite (mep^2), which is composed of katepimeron plus meron, back against the pleuron of the metathorax.

The numerous small plates which lie in the membrane surrounding the base of the wing are very difficult to see, but are easily identified with those sclerites outlined by Crampton (1914) in his ground plan of a typical thoracic segment in winged insects. The tegula (tg) lies in the angle between the scutum and the anepisternum. The notale (n) is a detached portion of the scutum lying just above the base of the wing. The basalar plates are two in number, the anterior one (aba) not demarked from the posterior portion of the anepisternum, the posterior one (pba) very small and lying between it and the pleural wing process (wp). The subalar plates are two in number, the anterior one (asa) lying behind the wing process and above the pteropleurite, the posterior one (psa) which is much smaller lying just below a posterior lateral process of the scutum. These basalar and subalar plates are the pre and post paraptera of Snodgrass (1909a).

The tergum of the metathorax, or the metanotum (n^3) is reduced to a narrow band connecting the halteres (ha), and visible only at the sides where it is produced to form points of

attachment for the abdomen. The pleuron of this segment is divided into metacpisternum (es^3) and metacpimeron (em^3). A spiracle (sp) is present just before the metacpisternum, as before the mesoepisternum. The region around the base of the haltere is so modified that it is impossible to tell whether pre and post alar bridges connect the metanotum with the metapleuron.

Some of the terms used above are different from those in common use among taxonomists. The mesoanepisternum (aes^2) has been called by dipterists the mesopleura. The mesosternopleurite (stp^2) is equivalent to the sternopleura of authors, while the meropleurite (mep^2) plus metapleuron plus metasternum equals the hypopleurite, so-called.

Chaetotaxy of the Thorax. The thorax of *T. pennipes* is not heavily armed with macrochætæ. However, representatives of most of the groups mentioned by Walton are present. Two humerals (hu) adorn each humeral callus. Posthumerals are wanting, as are anterior acrosticals. The anterior dorsocentral rows are represented by two very variable bristles (adc) placed near the hinder margin of the prescutum, while at each rear corner of this sclerite are borne two notopleural bristles (np). On each side, between the notopleurals and the anterior dorsocentrals, lies a single bristle, the presutural (psu).

On either side of the scutum a single bristle (sa) represents the supra-alar row, and another (ia) each intra-alar row. Two post alars (pa) are present, and each of the posterior dorsocentral (pdc) and posterior acrostical (pac) rows is represented by a single bristle. It will be seen that these last four bristles form a transverse row near the hind margin of the scutum. This is called the prescutellar row.

On the scutellum an anterior bristle and a posterior bristle mark the position of the marginal scutellar row (ms). The anterior bristle was seen to be accompanied by a smaller one in one or two specimens. No discal scutellars are present.

The mesoanepisternum bears a vertical row of bristles called the mesopleural row (mr), situated just before the membrane which divides it. Below the anterior spiracle are two

bristles, one on the prothorax, the propleural bristle (pp), and one on the sternopleurite, which the writer has called the substigmal bristle (ss). The sternopleurite bears typically two sterno-pleurals (stb), although a third was found to be present on some individuals. A curved row of three to five hypopleurals (hp) is located on the meropleurite. A single pteropleural bristle (ptb) was present in some specimens examined, while others bore as many as four.

Appendages of the Thorax.

Legs. Pl. I, fig. 4; Pl. II, figs. 7 and 8. The coxa (cx) is tawny in color, with a grayish bloom, while the trochanter (tr) and the proximal portion of the femur (fe) are yellowish. The distal portion of the femur and the tibia (tb) and tarsus (ta) are black. The claws are yellowish tipped with black, and are fringed with very fine light-colored hairs. There is a bristle-like empodium (ep) which, since it is a prolongation of a ventral plate, is a true empodium according to Crampton (1923). The pulvilli (pv) are buff-colored, and in the male are quite large and conspicuous. The first two pairs of legs display no features of particular interest. The tibiæ of the hind legs, however, exhibit on the outer side a peculiar row of black, feather-like setæ, which stand nearly erect, and the longest of which are at least one third the length of the tibia itself. This row is in reality double, since a row of smaller scales is appressed to the larger ones on the outside. The hind tibia also bears on its inner face a single bristle of a size noticeably larger than any of the surrounding hairs.

Wings. Pl. II, figs 5 and 6. The wings of the female are dusky, with the posterior margin sub-hyaline. Those of all the males examined bear a somewhat variable yellowish area in the forepart of the wing, the extent of which is indicated in figure 5. According to Coquillett (1897) this character is not constant.

The figure of the wing of the female (fig. 6) explains the venation of the wings, while the cells are labeled in the figure of the wing of the male. The chief point of interest in the wing venation of *T. pennipes* is that M_3 is bullate or weakened basally, making M_3 appear as a stub sticking up from Cu_1.

Abdomen. Pl. II, figs. 9-14. Pl. III, fig. 15. The abdomen in both sexes is of a bright orange color and is destitute of macrochætæ. It is sparsely clothed, however, with short black hairs. Seven pairs of spiracles (sp) are present, borne at the lateral margins of the tergites (t_1, t_2), etc.). Those of the sixth and seventh segments are hidden beneath the posterior edge of the fifth tergite (t_5). The tergites of the first and second segments are fused, the fusion being denoted by an area of weaker chitin, which is demarked in the figures by a pair of dotted lines between t_1 and t_2. The adventitious suture (as) in the first tergite, mentioned by Young, is readily seen.

The tip of the abdomen in the female is wholly black, this coloration including the fifth tergite and in some individuals extending further forward to include part of the fourth tergite. The terminal abdominal segments of the male in specimens examined by the writer were in no case wholly black, although t_5 and t_6 were darker than those preceding.

Genitalia.[1] Pl. II, figs. 13-14; Pl. III, fig. 15. In both sexes the segments beyond the fifth abdominal may truly be called genita segments. In the male these segments curve downward and come to lie beneath the fifth tergite. In the female those beyond the fifth are telescoped when at rest, being extended for oviposition.

In the male the fused tenth and eleventh tergites, which are ventral in position, act as a cover for the œdeagus (oe), being tucked beneath the edge of the fifth sternite (s_6) when at rest. When the œdagus is extruded, however, this flap lifts up, allowing the ninth sternite (s_9) to push forth. This latter segment is very much modified. Its fused cerci are median in position and form the œdagus, a very complicated structure which encloses the membranous penis. At the base of the œdagus are seen two pairs of lateral projections, called gonopophyses (go), the inner pair of which are hyaline. They are well-chitinized, however, feeling hard to the touch of a dissecting needle. At the base of the œdagus the ninth sternite is

[1]The writer has based his description of the genitalia largely on the condition of these structures in generalized insects. It is apparent that the study of a series of dipterous genitalia may reverse some of his decisions regarding the true character of the parts.

rather more heavily chitinized than elsewhere, resulting in the appearance of a chitinized box (chb) from which the ædeagus protrudes and on which the gonopophyses are borne. This chitinized box also bears a median dorsal hook-like projection, called by the writer the genital prong (gp). The styli of the ninth segment, which in some insects function as outer claspers, are here much reduced in size and are apparently non-functional, since when the genitalia are extruded they barely appear beyond the posterior edge of the eighth tergite. A peculiar structure, which the writer is at a loss to homologize with any genital appendage of generalized insects, appears in the "genital furca" (gf). This is a fork-like chitinized rod which lies between the sides of the ninth sternite, to which it is connected by muscles. It splits at the base of the œdagus, one arm extending to either side of the latter organ. Its function is quite evidently that of guiding the movements of the œdagus.

In the female the eighth segment is a narrow ring, bearing below the median ventral valve (vv) of the ovipositor and laterally the two inner valves (iv). Dorsally this segment seemed to bear a median dorsal valve (dv), but this may prove to be a modified portion of the ninth segment, which is supposed to bear the dorsal valve. This point could not be definitely determined from the dried material at the writer's disposal, even after soaking in caustic potash and gently extending the ovipositor by pushing from within by means of a blunt needle.

Secondary Sexual Characters. The foregoing account of the external anatomy of *Trichopoda pennipes* contains scattered references to certain differences which were apparent between the two sexes. These differences were constant in a series of eight males and seven females. Scarcely any difference in size could be noticed, the males averaging 8.6 mm. in length, the females 8 mm. Both the largest and the smallest were males, the one 10 mm. long, the other measuring 7 mm. To a certain extent the size of the adult fly is affected by the abundance of food available to the larva which preceded it, and when contained in keys for the identification of species may be found misleading.

Two characters were found by which the sex of living flies can be determined without undue handling. These are the ferrugineous spot in the wing of the male as against the evenly dusky wing of the female, and the black tip of the female abdomen as against the dark orange of that of the male.[1] A minor difference was in the size of the pulvilli, these being shorter than the last tarsal segment in the females, and inconspicuous. In the males the pulvilli were longer than the last tarsal segment and quite broad and conspicuous. This is a character, however, that is not readily noticed unless a male and a female are examined at the same time, and it is therefore of little practical use, in a taxonomic sense.

Egg. Pl. III, fig. 16.

The eggs of *Trichopoda pennipes* vary in color from clear shining white to dirty gray, the coloration seeming not to depend on the age of the egg. The individual egg is ovate in outline being slightly larger at one end. It is strongly convex, and is flattened on the side next the body surface of the host. This flattened surface is covered by a colorless cement, by which the egg is affixed to the body of the host. The egg measures .56 mm. in length by .37 mm. in breadth, and its greatest height is .25 mm. The surface of the chorion appears smooth except under high magnification, when it is seen to be faintly reticulate in tiny hexagons. The chorion is comparatively thick and "leathery", and remains rigid after hatching. The micropyle appears to be borne on a small papilla at the smaller end of the egg. Eggs which have hatched show a circular hole on the flattened side near the broader end. Since it is this flattened side which is pressed against the host, it is impossible to tell if an egg has hatched without first removing it from the body surface of the host.

Larva. Pl. III, figs. 17 and 18.

The larva has not been examined in all instars. When full-grown, it is a dead-white maggot, with black hook-like

[1] Drake (1920) published recognizable photographs of both sexes, but his designations are erroneous. Osten Sacken, in a foot-note to the work of Say (1829), also has confused the sexes.

rasping mouth parts (mh) and a pair of black anal stigmata. (ans) It is quite robust, and although its greatest circumference is about midway of its length, it can hardly be called fusiform, since it tapers away to a point in front, while the anal end is blunt. It is about 10 mm. long by 3.5 mm. in diameter, a surprising size when one considers that the adult host measures but 15 mm. in length.

The structure of the cephalo-pharnygeal skeleton, and the arrangement of the slits in the anal stigmata vary in the different species, and figures of these organs are therefore included in the plates. No sign of the parastomal sclerites mentioned by Banks (1912) as occurring in certain muscoid larvæ could be found in the cephalo-pharyngeal skeleton of *T. pennipes*.

PUPARIUM. Pl. III, figs. 19, 20, 21.

The pupa itself has not been observed. The puparium which encloses it, however, is of a deep reddish-black color, cylindrical in shape, and rounded at both ends. It is formed from the skin of the mature larva, and upon it the anal stigmata appear as twin tubercles at the posterior end. The puparia average about 7.5 mm. in length and 3.5 mm. in diameter. At the anterior end, before the emergence of the adult fly, a transverse split occurs, reaching backward nearly a quarter of the length of the puparium. The split then extends around the circumference, this resulting in the formation of two flaps which are pushed aside by the ptilinum of the emerging adult.

Some time after the examinations of the puparium had been finished by the writer, the work of Greene (1922) on the puparia of muscoid flies came to hand. The puparium of *T. pennipes* is there figured and discussed, and significant characters compared with those of the puparia of other species.

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Explanation of Figures.

Plate I.

Fig. 1. Head of male—front view.
Fig. 2. Head of male—side view, showing mouth parts.
Fig. 3. Dorsum of male thorax.
Fig. 4. Thorax of male—side view.

Plate II.

Fig. 5. Wing of male, showing extent of ferrugineous spot. Cells labeled.
Fig. 6. Wing of female. Veins labeled.
Fig. 7. Tibia of metathoracic leg, showing fringe of feather-barbed setæ.
Fig. 8. Terminal segments of tarsus of male.
Fig. 9. Abdomen of male—side view.
Fig. 10. Abdomen of female—side view.
Fig. 11. Abdomen of male—ventral view.
Fig. 12. Abdomen of female—ventral view.
Fig. 13. Male genitalia.
Fig. 14. Female genitalia.

Plate III

Fig. 15. Ninth abdominal sternite of male.
Fig. 16. Egg. a, outline from side; b, from top; c, showing hole in ventral surface after hatching.
Fig. 17. Mature larva.
Fig. 18. Cephalo-pharyngeal skeleton of larva. a and b, of second stage (?) larva, side and top views; c and d, mature of larva, side and top views.

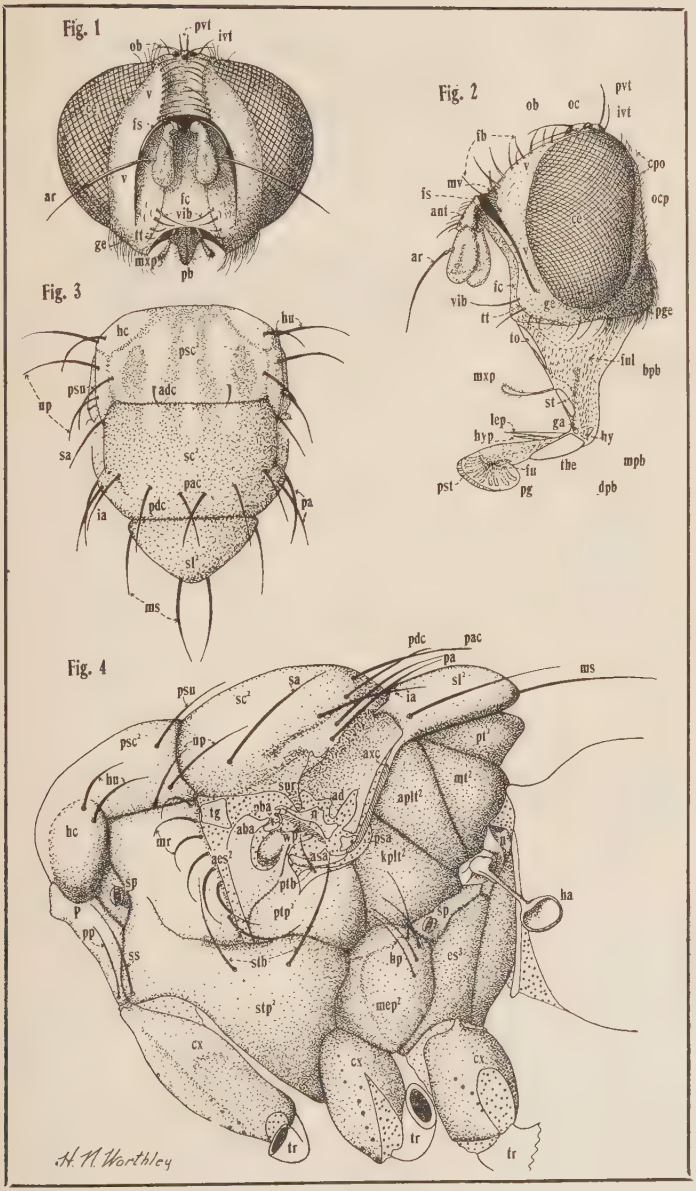
Fig. 19. Puparium, from the top.
Fig. 20. Empty puparium, from the side.
Fig. 21. Anal stigmata of puparium.

Plate IV

Dorsal view of male fly.

Abbreviations

1st A	—anal or 6th longitudinal vein	fb	—frontal bristles
aba	—anterior basalar plate	fc	—fronto-clypeus (facial depression, facial plate)
ad	—adanale	fe	—femur
adc	—anterior dorso-central bristle	fs	—frontal suture
ae	—oedagus	fu	—furca
aes^2	—mesoanepisternum or mesopleura	ful	—fulcrum
aex	—axillary excision	ga	—galea
al	—axillary lobe	ge	—gena (cheek)
ans	—anal stigmata	gf	—genital furca
ant	—antenna	go	—gonopophyses
aplt^2	—anapleurotergite of post-scutellum	gp	—genital prong
ar	—arista	ha	—haltere
as	—adventitious suture	hc	—humeral callus
asa	—anterior subalar plate	hcv	—humeral cross-vein
AxC	—axillary (or anal) cell	hp	—hypopleural bristles
axc	—axillary cord	hu	—humeral bristles
bpb	—basiproboscis	hy	—hyoid
bu	—button	hyp	—hypopharynx
C	—costal vein	hys	—hypostomal sclerite
CC	—costal cell	ia	—intra-alar bristle
ce	—compound eye	iv	—inner valve of ovipositor
chb	—chitinized box	ivt	—inner vertical bristle
cpo	—cilia of posterior orbit	kplt^2	—katapleurotergite of post-scutellum
CuC	—cubital (3rd basal or anal) cell	lep	—labrum-epipharynx
Cu_1C	—3rd posterior cell	lp	—lateral plate
cx	—coxa	M	—media
dpb	—distiproboscis	m	—medial (posterior)cross-vein
dv	—dorsal valve (?) of ovipositor	M_{1+2}	—4th longitudinal vein
		$M_{3+}Cu_1$	—5th longitudinal vein
em^2	—metaepimeron	MC	—medial (2nd basal) cell
ep	—empodium	$1M_2C$	—discal cell
es^3	—metaepisternum	$2M_2C$	—2nd posterior cell



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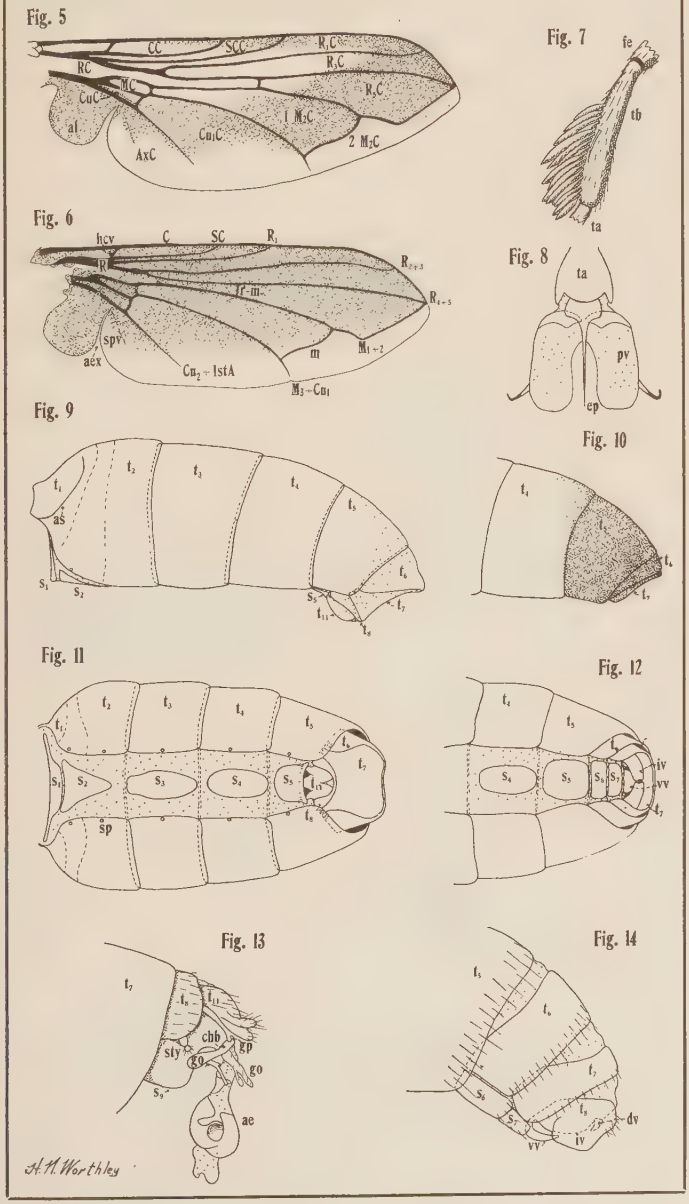
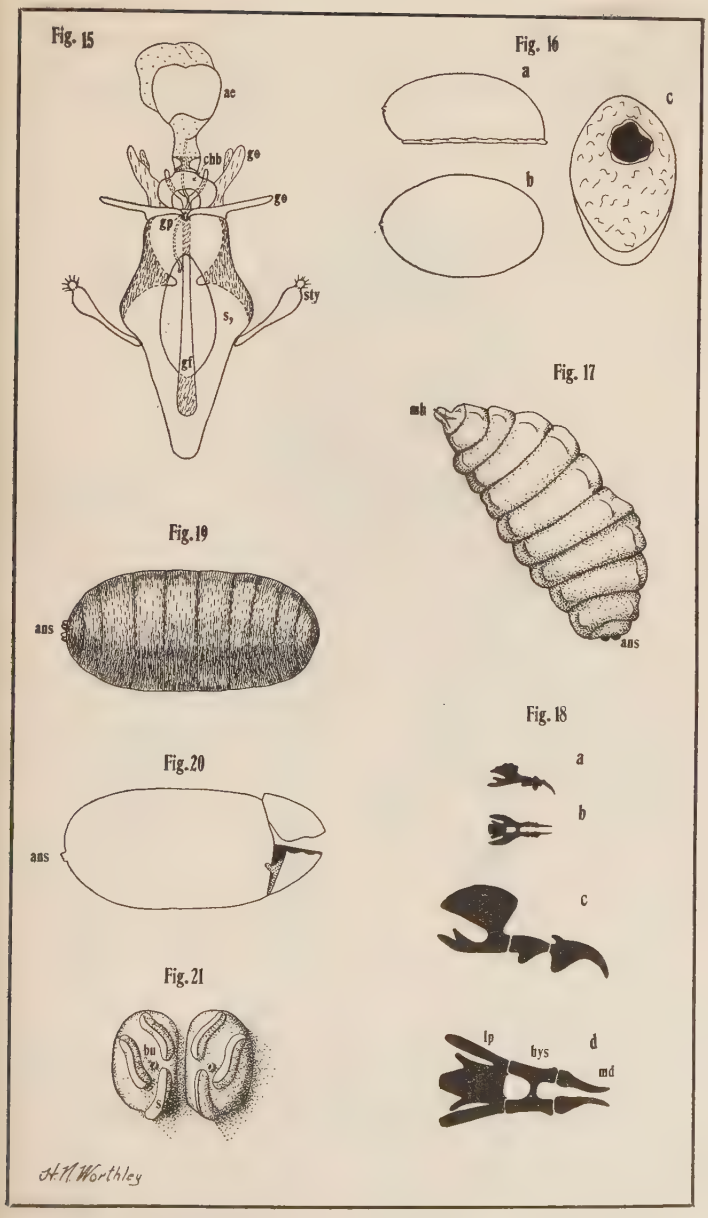
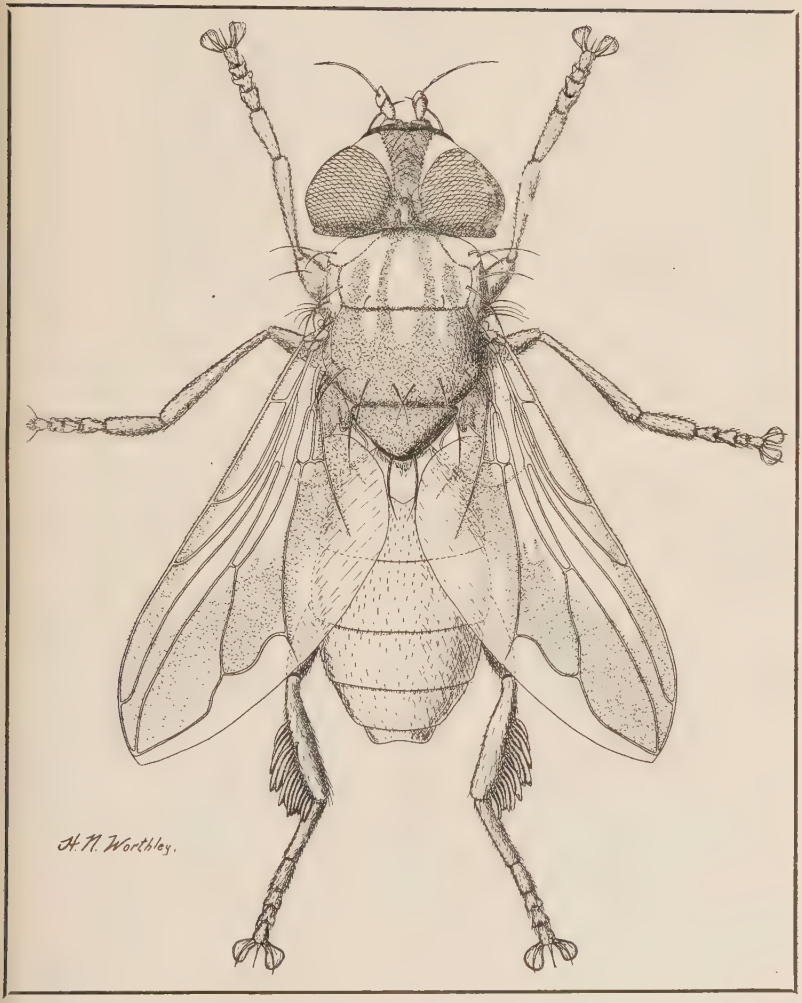


WORTHLEY—Biology of *Trichopoda pennipes*



WORTHLEY—Biology of *Trichopoda pennipes*



WORTHLEY—Biology of *Trichopoda pennipes*

md —mandibles (great hooks) of larva
mep² —meropleurite
mh —mouth hooks (or mandibles) of larva
mpb —mediproboscis
mr —mesopleural row
ms —marginal scutellar bristles
mt² —meditergite of postscutellum
mv —median vitta of vertex
mxp —maxillary palpus

n —notale
n³ —metanotum
np —notopleural bristles

ob —ocellar bristles
oc —ocelli
ocp —occiput

P —prothorax
pa —postalar bristles
pac —posterior acrostical bristle
pb —proboscis
pba —posterior basalar plate
pdc —posterior dorso-central bristle
pg —paraglossae
pge —postgenae
pp —propleural bristle
psa —posterior subalar plate
psc² —mesoprescutum
pst —pseudotrachae
psu —presutural bristle
pt² —posttergite of mesoscutellum
ptb —pteropleural bristle
ptp² —pteropleurite or mesoan-epimeron
pv —pulvillus
pvt —posterior vertical bristles

R —radius
R_1 —1st longitudinal vein
R_{2+3} —2nd longitudinal vein
R_{4+5} —3rd longitudinal vein
RC —radial (1st basal)cell
R_1C —marginal cell
R_2C —submarginal cell
R_3C —1st posterior or apical cell
r-m —radio-medial (anterior) cross-vein

s —slit
s_1, s_2, etc. —abdominal sternites
sa —supra-alar bristle
sb —scutellar bridge
SC —subcosta (auxiliary vein)
sc² —mesoscutum
SCC —subcostal cell
sl² —mesoscutellum
sp —spiracle
spv —spurious vein
ss —substigmal bristle
st —stipes
stb —sternopleural bristles
stp² —mesosternopleurite (sternopleura)
sty —stylus
sur —suralare

t_1, t_2, etc. —abdominal tergites
ta —tarsus
tb —tibia
tg —tegula
the —theca
to —tormae
tr —trochanter
tt —tentorial thickenings

v —vertex
vib —vibrissae
vv —ventral valve of ovipositor

wp —wing process

REVIEW OF THE DIPTEROUS FAMILY PIOPHILIDÆ.[1]

By A. L. Melander.

Pullman, Washington.

In 1917 in collaboration with Anthony Spuler I published a taxonomic study of the Piophilidæ in Bulletin 143 of the Washington Agricultural Experiment Station. This work was undertaken in order to facilitate identification in this group of insects many of which are of concern to man owing to their unsanitary habits of frequenting garbage. In the meantime additional collecting has brought to light several undescribed species which are herewith described together with some notes on the taxonomy of *Piophila* and a rectification of the identity of *P. pusilla*.

Key to the Species of Mycetaulus.

Thorax wholly reddish yellow, or almost entirely so; abdomen more or less blackened.. ..... 2.

Body almost wholly black; wings uniformly subhyaline..... 7.

2. Occiput brownish; wings more than three times as long as broad; pectus, metanotum and an anterior spot on mesonotum sometimes blackish. (Can.; E. U. S)..... *longipennis* Loew

Head yellowish or rufous; wings three times as long as wide..... 3.

3. Anterior crossvein distinctly beyond middle of discal cell... 4.

Anterior crossvein located near middle of discal cell ..... 6.

4. Costal cell blackened; ocellar area concolorous with head... 5.

Costal cell hyaline; ocellar area black (E. U. S.)..... *pulchellus* Banks

5. Costal area narrowly black from root of wing to tip, the apical spot excised in submarginal cell. (Or.)..*costalis*, n.sp.

Costa not centrally blackened, the apical spot somewhat triangular. (Eur.; W. U. S.)..... *bipunctatus* Fallen

[1]Contribution from the Zoology Laboratory of the State College of Washington.

6. One dorsocentral bristle; cilia of calypteres white; wings uniformly subhyaline; front tibiæ yellowish; (W. U. S.) *testaceus*, n. sp.

   Two dorsocentrals; cilia of calypteres brown; wings with narrow clouding at apex; front tibiæ brown. (Wash.) *polypori*, n. sp.

7. Pleuræ, scutellum and end of abdomen reddish (Eur.) *analis* Meigen

   Pleuræ, scutellum and abdomen black, only prothorax and humeri yellowish; front yellow. (W. U. S.) *nigritellus*, n. sp.

Mycetaulus costalis, n. sp.

Male. Length 3 mm. Front reddish, occiput, face and cheeks testaceous, thorax luteous, abdomen black. Front tapering, slightly longer than width at anterior ocellus where it is twice as wide as at antennæ, posterior fronto-orbital strong. Notal hairs moderately scattering. Retracted genitalia black. Legs including coxæ mostly pale yellow, last tarsal joint dusky. Halteres white, calypteres dirty, with black fringe; wings mainly clear hyaline, costa, first vein and end of second and third veins black, remainder of veins yellowish, anterior edge of wing bordered with black which also borders the black tips of the second and third veins, costal cell wholly black, anterior crossvein about one-fourth the length of the posterior and located near two-thirds the length of the discal cell.

Holotype, North slope of Mt. Hood, Oregon, 29 July, 1921, at 3000 feet elevation.

Mycetaulus nigritellus, n. sp.

Male. Length 3 mm. Head bicolored, thorax and abdomen black, front legs partly black, wings uniformly but lightly brownish hyaline. Upper two-thirds of occiput black continuing forward on the ocellar triangle and as orbital stripes to the posterior fronto-orbital bristle, remainder of front luteous, face, cheeks and lower orbits pale yellow, lower setulæ indistinct, clypeus narrowly brown, antennæ luteous, the upper part of third joint

brownish, arista blackish. Pectus and the part of the pleuræ above front coxæ brownish yellow, sometimes humeri brown, notal hairs minute and sparse, two strong sternopleurals. Base of abdomen subshining at sides, remainder of abdomen polished, genitalia small and retracted. Front coxæ whitish, basal half of front femora yellow, apical half black, ten flexor setæ, base of front tibiæ yellowish, remainder black, front metatarsi black, other joints yellowish, posterior legs yellowish, the hind femora distally slightly brown. Halteres, calypteres and fringe and root of wings whitish; wings rather pointed, veins brown, first posterior cell two-thirds as wide as submarginal on the costa, anterior crossvein at three-fifths the length of the discal cell and one-third as long as posterior crossvein.

Female. Front tarsi wholly black, the metatarsus somewhat thicker than the other joints; ovipositor terete.

Types. Lookout Mt., Priest Lake, Idaho, 20 August, 1919, paratypes, Lake McDonald, Glacier Park, Montana; Moscow Mt., Idaho; and Mt. Spokane, Washington; July-September; fifteen males and six females.

Mycetaulus polypori, n. sp.

Male. Length 3.5 mm. Head and thorax testaceous, abdomen blackish, legs mostly testaceous yellow, the distal part of front femora and tibiæ and the front tarsi blackish, wings narrowly blackened at apex. Antennæ pale yellow, arista brown, occipital black setulæ conspicuous; front wider than long and two-thirds as wide at lunule as at ocelli. Thoracic hairs fine and rather abundant, bristles long, two dorsocentrals. Base and apex of abdomen and venter yellowish brown, genitalia small, with spiral yellow filament. Front coxæ yellow, sometimes the front femora lack the darkening at the apex. Halteres white, calypteres yellowish white, the fringe brown; wings yellowish hyaline, auxiliary and first vein, distal end of second, third and fourth veins and apical part of costa blackish, remainder of veins yellowish, a narrow blackish cloud following

the blackened portions of the veins at the apex of the wing, anterior crossvein at middle of discal cell and a little shorter than half the length of the posterior crossvein.

Types, twenty-six males and eleven females, in the vicinity of Longmire, Mt. Rainier, Washington, July, 1922. The specimens were taken disporting themselves on the underside of the shelf-fungus, *Polyporus*, growing on tree-trunks in the shady woods. They would not readily take to flight but were secured by suddenly blowing them into the net.

Mycetaulus testaceus, n. sp.

Male. Length 3.5 mm. Head and thorax entirely testaceous abdomen black, legs yellowish with the front tarsi and apical joints of posterior tarsi black; wings uniformly subhyaline. Occiput dull, its setulæ black; front wider than long, its setulæ fine and black. Hairs of mesonotum very fine and abundant, black, only the posterior dorsocentral developed; abdomen truncate at tip, genitalia small, without processes. Calypteres fringed with white hairs, halteres white; costa and first vein blackish, other veins yellowish at base, becoming darker distally, two apical sections of costa subequal, anterior crossvein very slightly beyond middle of discal cell, one-third as long as posterior crossvein.

Type, Moscow Mt., Idaho, 24 June 1919; two paratypes, Ilwaco, Washington, May and July.

The single dorsocentral bristle suggests *Piophila* were it not that the humeral and presutural bristles are strong as in *Mycetaulus*. Location in this genus is further indicated by the yellow body-color, two strong sternopleurals, long cephalic bristles and undoubted relationship to *M. polypori*.

Prochyliza brevicornis, n. sp.

Similar to *P. xanthostoma* in coloration except that the yellow of the face continues over the antennæ across the anterior part of the front. This yellow portion of the front curves down.

The second antennal joint is about one-half the length of the third. There are three or four black setæ on the lower part of the front coxæ.

This is the form mentioned in Bulletin 143 of the Washington State Agricultural Experiment Station, page 56, as superficially resembling *Piophila affinis*. Insamuch as I have taken seventeen specimens all constant in the correlation of characters given above the form may be given specific rank. The localities represented are Yellowstone Park, several places, Flathead Lake, Montana, and Chicago, Illinois; all captured in July or August.

P. xanthostoma has the front entirely black and plane or convex to the lunule. In only one specimen is there any yellow color above the antennæ. The second antennal joint is extremely variable but always is longer in proportion to the third joint than in this brachycerous form. The coxal setæ are present in the male but are undeveloped in the female. In *Piophila affinis* the venter of the male is shaggy with black hair, which is not the case in *Prochyliza*.

Subgenera of Piophila.

The genus *Piophila* was based on *P. casei* as genotype but the inclusion of many subsequently described species has caused it to become heterogeneous. In line with the present tendency to recognize finer distinctions Hendel in 1917 segregated the genus *Allopiophila* from the group, basing it entirely on chætotactic characters. *Piophila casei* and a few of its congeners are markedly different from the majority of the species left in *Piophila*. Removal of the species grouped with *P. casei* and the separation of those in *Allopiophila* makes it necessary to revive Lioy's name *Stearibia*, founded on *foveolata* Mg.=*nigriceps* Mg. As the size of bristles is quite variable the diagnostic characters have only relative and not absolute value. Hence it is premature to assign more than subgeneric rank to these names.

In order to show the relationships of the species of *Piophila* with reference to the divisions into subgenera and to facilitate identification of several new forms the following table is presented.

Five species not represented in my collection are omitted since their descriptions are too brief to show phyletic location in the key. The omitted species are: *P. concolor*, a red species probably a Cordylurid; *nitens*, perhaps a *Pseudodinia*; *senescens*, vaguely recorded by Macquart in 1851 as from North America and not since recognized, possibly not *Piophila* since it is gray pubescent; and the Greenland hairy species *pilosa* and *nigerrima*.

Key to the Subgenera and Species of Piophila.

Mesonotum finely scabrous, centrally not pubescent but with three rows of setulæ, one in the middle and one on each dorsocentral row; fronto-orbital, humeral, presutural and sternopleural bristles undeveloped; ocellar bristles small, widely distant and located opposite the front ocellus, the ocellar triangle differentiated as a shining space on the satiny front; vertical bristles small; mesopleuræ sparsely hairy; pygidium transverse, retracted within the fifth segment and asymmetrically excised toward the right side; cheeks more than half the eye-height; second and third joints of front tarsi subequal to metatarsus. Subgenus *Piophila* Fallen, *s. str.* Genotype and only American species, cosmopolitan. *casei* Linn.

Mesonotum smoothly polished and uniformly pubescent; ocellar bristles located behind the front ocellus; cheeks less than half the eye-height; sternopleural bristles usually present, though small; front metatarsi longer than two following joints together . . . . . 2.

2 Fronto-orbital, humeral and presutural bristles minute or wanting; mesopleuræ usually sparsely hairy; pygidium retracted and cleft toward the right side, *i. e.* the sixth segment displaced: lower occiput black or blackish, with a pruinose vertical stripe below the eyes abruptly stopping in a vertical line on the cheeks. (if occiput is shining, front blackened on upper three fourths, legs mostly black, and antennæ dark above, see *Prochyliza brevicornis*, n. sp.) Genotype *P. nigriceps* Meig. Subgenus *Stearibia* Lioy . . . . . 3.

One or two fronto-orbitals, humeral and presutural bristles well developed; mesopleuræ bare; pygidium pendant and extending forward under abdomen, the sixth segment superior; back part of cheeks shining, no pollinose vertical stripe beneath the eyes. Genotype *P. luteata* Hal. Subgenus *Allopiophila* Hendel.....9.

3. Scutellum flattened and microscopically roughened; front entirely black and devoid of pubescence; veins thin and pale. (Eur.; N. Am.).....*nigriceps* Meigen.

Scutellum convex and smooth; front more or less yellow or red.....4.

4. Front coxæ yellow.....5.

Front coxæ entirely black; femora black except knees, front tibiæ blackish, their tarsi black.....8.

5. Venter of male heavily hairy; sixth abdominal segment large and convex; posterior legs in large part black; upper half of front black; hind metatarsi subequal to remaining joints together.....6.

Venter with short sparse hairs; sixth abdominal segment of male not strongly convex; hind metatarsi shorter than remaining joints together; front yellow quite to the vertex.....7.

6. Halteres yellow. (Eur.; Mass., Ont., Wash.).*affinis* Meigen.

Halteres tipped with black.(Wash.).*affinis*, var.*halterata* M.,S.

7. Posterior legs yellow: cheeks, antennæ, base of arista and mouthparts yellow (N. U. S., B. C.)..*privigna*, n., sp.

Posterior legs in large part black; cheeks, antennæ, arista and mouthparts piceous. (Wash.)....*morator* n. sp.

8 Mouthparts, cheeks, face, half of front and antennæ yellowish; halteres entirely yellow. (Mont., Id., Wash.) *nigricoxa* M., S.

Mouthparts, cheeks, face and antennæ black, anterior half of front deep reddish: halteres with blackened tip. (Ill.).....*occipitalis* M., S.

9. Front coxæ yellow; yellow of front continuing as an M-shaped mark to vertex; at least posterior fronto-orbital strong.....10.

Coxæ black; fronto-orbital weak.....14.

10. Wings hyaline, veins yellowish.....11.
Wings with dark apical cloud, veins brown; abdomen closely and finely scabrous. (Mont., Ida., Wash.) *liturata* M., S.

11. Sixth segment of male abdomen pruinose; cheeks one-third eye-height; base of arista brown; propleural bristle strong.....12
Sixth segment shining; legs typically wholly yellow except tips of tarsi: cheeks less than one-third eye-height; arista black; propleural bristle weak. (Mont., Ida., Wash.).....*xanthopoda* M., S.

12. Front legs black except coxæ and knees, posterior femora mostly black. (Mass., N. Y.).....*oriens* M., S.
At least base of front femora yellow, posterior legs mostly yellow.....13.

13. Legs almost wholly yellow; lower occiput yellow. (Alaska) *setosa* M., S.
Front legs black beyond middle of femora, excepting knees; lower occiput largely black. (Eur.; Wash.) *pusilla* Meigen

14. Posterior femora and all tibiæ yellow, front metatarsi merging in color with remaining joints; front reddish toward antennæ. (Wyo., Mont., Ida., Wash., Cal.) *nitidissima* M., S.
All femora black except narrowly at knees, first joint of front tarsi yellow sharply contrasting with black remainder: front entirely black. (Ida., Wash.) *atrifrons* M., S.

Piophila morator, n. sp.

Male. Length 2.75 mm. Front testaceous, vertex, ocellar triangle, upper orbits and occiput piceous black, cheeks, face, mouthparts and antennæ brown, the antennæ appearing velvety with cinereous pubescence; a vertical gray pruinose stripe beneath eyes, cheeks at middle one-fourth the eye-height; base of arista brown, remainder black; interfrontal pubescence distinct

but sparse and pale, bristles weak. Humeral, presutural and sternopleural bristles undeveloped, prothoracic bristle weak; hairs of meso- and sterno-pleuræ present, propleuræ heavily pruinose. Abdomen bluntly elliptical, ventral hairs short and sparse, pygidium retracted, cleft on right side. Front coxæ yellowish, posterior coxæ piceous, legs piceous except the yellowish knees and posterior tarsi. Halteres nearly white. Wings hyaline, veins pale.

Holotype, Pullman, Washington, May.

Piophila privigna, n. sp.

Male. Length 3 mm. Front light yellow up to the vertex, the small ocellar triangle and the uppermost orbits black, occiput shining black, its lower sides with a white pruinose stripe extending from the eyes to the oral margin, face, cheeks, mouthparts and antennæ light yellow, arista brown, paler at base; cheeks broad, at middle one-third and at pruinose stripe one-half the eye-height; interfrontal hairs sparse and yellow, ocellar and postvertical bristles small, no fronto-orbitals. Thorax polished black with bluish lustre, no humeral, presutural or sternopleural bristles, notal pubescence uniform, meso- and sternopleuræ with scattering hairs, scutellum convex, prothoracic bristle small, propleuræ heavily pruinose. Abdomen polished black with blue lustre, the sixth segment displaced so that the retracted pygidium appears cleft, ventral hairs short and sparse. Legs light yellow, the distal two-thirds of front femora black and the distal three-fourths of front tibiæ brown. Halteres whitish. Wings hyaline, veins pale yellow.

Female. Front tarsi black.

Types, four males and eight females; Woods Hole, and New Bedford (Hough) Mass.; Cold Spring Harbor, N. Y.; Chicago, Ill.; Sheridan (Metz), Wyo.; Potlatch, Ida.; Pullman, Colfax, Ilwaco, Wash.; Nelson, B. C.: July and August. This is the species recorded as *P. pusilla* in Bulletin of the Washington State Agricultural Experiment Station No. 143, p. 61., under which name the other specimens there listed have been distributed among collections. I have taken the real *pusilla* at Olympia, Wash.

NOTES ON PHORIDÆ FROM SOUTH AFRICA.[1]

By Charles T. Brues.

During the past summer I received from H. K. Munro, Border Entomologist of the Union of South Africa, a small collection of Phoridæ obtained by him in the Cape Province.

As he wishes to publish observations on the life-history of some of the species included, I am taking this opportunity to present descriptions of two new species and taxonomic notes on some of the others.

Hypocera vectabilis Brues.

Ann. Mus. Nat. Hungarici, vol. II, p. 1 (1913)

There are numerous specimens of both sexes agreeing in all particulars with this species originally described from Abyssinia. More recently Schmitz has described *Hypocera trinervis*[2] from Stanleyville, Congo, which he says is related to *H. vectabilis*, and which I cannot distinguish from his description. The single male was taken in a nest of *Sima æthiops* on *Barteria fistulosa* and Schmitz thinks that *trinervis* is probably myrmecophilous. The original specimens of *H. vectabilis* were reared from the bodies of dried beetles shipped from Abyssinia to the Hungarian National Museum in Buda-Pest.

Some of Mr. Munro's specimens were "bred from larvæ infesting fruits of *Solanum sodomeum*" at Prospect, Komgha, Cape Province, March-April 1923, and others were taken in his office during April and May.

Aphiochaeta picta Lehmann

There are two typical specimens (♂ ♀) collected by Dr. Munro at East London, July 26, 1922 and April 29, 1923. This common palæartic species is known also from America, but it has

[1]Contribution from the Entomological Laboratory of the Bussey Institution, Harvard University. No. 235.

[2]Deutsche entom. Zeits., 1915, p. 498.

not hitherto been reported from Africa (*cf.* Schmitz, Jaarb. Natuurhist. Genootsch., Limburg for 1914, pp. 108-109 (1915) and Brues (Bull. Wisconsin Nat. Hist. Soc., vol. 12, p. 126 (1915).

Aphiochaeta setifer, sp. nov.

♂. Length 1.5 mm. Head and thorax piceous, lower part of front and anterior part of mesonotum fuscous; abdomen black; antennæ fuscous; palpi pale yellowish: legs brownish yellow, the hind femora blackened at tips and their tibiæ with a black line above; hypopygium brownish, pruinose; wings hyaline, with a brownish tinge apically on the disc; venation dark brown. Front slightly but distinctly higher than wide; lower pair of post-antennal bristles very small, half as far apart as the upper pair which are nearly as large as the other frontal bristles and placed almost as far from one another as from the eye margin; bristles of lowest reclinate row with the inner one on a level with the upper post-antennal and one-third way toward the eye, the outer bristle very close to the eye and well above the inner one; upper row evenly spaced with the lateral one close to the eye, forming a slightly curved series across the upper third of the front; ocellar row of four bristles evenly spaced; ocellar triangle clearly elevated and delimited. Antennæ small, oval; arista as long as the eye. Palpi with four long and two short bristles. Proboscis very small. Post-ocular cilia strong, slightly enlarged below, cheek with a pair of strong bristles. Mesonotum highly shining, with one pair of dorsocentral bristles; scutellum with a single marginal pair. Abdomen dull, slightly pruinose; second segment elongated, with a couple of weak bristles at each side: fifth and sixth segments sparsely clothed with small black bristles. Hypopygium covered with minute bristles, but with no larger ones; apical lamella short. Ventral side of sixth segment bristly. Propleura along its posterior edge with a series of bristles, enlarged above and near the front coxa; mesopleura bare. Four anterior coxæ conspicuously bristly at tips; hind femora with a series of longer hairs below. Middle tibiæ with a line of seven or eight distinct but delicate

setæ inside the posterior edge; hind tibia with a similar series of seven much larger ones, which are considerably longer than the width of the tibia, excepting the basal two which are much shorter. Costa barely less than four-ninths of the wing length, its bristles long (four times the width of the costal vein) and sparsely placed (five beyond the tip of the first vein); first section of costa slightly longer than the second and third together; third two-thirds the length of the second; second vein emerging from the third at a very acute angle; fourth vein faintly curved at base, straight beyond; fifth and sixth nearly straight; seventh weakly curved, well removed from the margin. Wing rather long and narrow. Halteres with black pedicel and light brown capitulum.

Type from Barberton, Cape Province, South Africa, May 22, 1913.

This species resembles the European *Aphiochæta fuscohalterata* Schmitz, but is at once distinguished by the large bristles on the hind tibiæ. It is similar to *A. decipiens* Wood (=*cilipes* Wood), but the bristling of the hypopygium will readily separate it from that species. It resembles *A. atrita* Brues from Java in color and many characters, but the ciliation of the hind tibia is very much stronger.

Puliciphora africana Brues (Fig. 1)

Ann. Mus. Nat. Hungarici, vol. 5, p. 410, fig. (1907)
Brues, Psyche, vol. 17, p. 36 (1910)

Numerous specimens of both sexes are referable to this species, described from females obtained at Kibosho, German

Fig. 1. *Puliciphora africana* ♂ wing.

East Africa. The several species of this quite cosmopolitan genus are extremely similar, and as they are attracted to and probably breed in old cheese, meat and other animal products, some have undoubtedly been widely spread by commerce particularly in the tropics.

To the original description of the female the following may be added from the well preserved specimens sent by Dr. Munro. There are four large divergent supra-antennal bristles, each longer than the diameter of the antenna; the lower pair are proclinate, the upper pair erect or slightly proclinate, set farther apart than the lower ones; above these are ten other bristles, one on each side of the front midway between the upper post-antennals and the eye, a median pair just below the ocelli, an ocellar row of six. The thorax bears six bristles, one at each anterior angle, one at each posterior angle and two very widely separated ones along the posterior margin. Pleura just below the posterior lateral bristle of the mesonotum with a very large bristle that projects laterally. In addition the head, thorax, abdominal plates and legs are rather densely clothed with fine black hairs.

Male. Considerably larger than the female, 1.7-1.8 mm. in length; wings large, approximately as long as the body. Head pale brownish, darker between the ocelli; thorax pale brown above, ochre yellow below; abdomen piceous above, whitish below, the hypopygium piceous, with brownish ventral lamella and pale dorsal one. Front with four supra-antennal bristles: the lower pair close together and clearly proclinate; the upper pair twice as far apart, strongly divergent and nearly porrect; above these there are 12 other bristles, a pair slightly above the post-antennals on each side of the front of which the lateral bristle is close to the eye and above the inner one, a pair just below the ocelli, and six forming a series of three pairs on the vertex above the ocelli. Post-ocular cilia much enlarged; cheek with a series of conspicuous forwardly directed bristles forming a line parallel with the lower eye-margin; palpus with about six moderate bristles; proboscis projecting, obtusely pointed, more slender than in the female. Third joint of antenna broadly

ovate, as long as thick and less than half as long as the eye-height; arista apical, faintly pectinate, as long as the front coxa. Mesonotum with one pair of very widely separated dorsocentral bristles and four scutellar bristles of which the median (not lateral) pair is often much smaller. Abdomen clothed with minute, almost imperceptible bristly hairs, more distinct on the apical segment, and enlarged to form a very evident apical row along the posterior margin of the other segments; venter entirely membranous, without hairs or bristles. Central portion of hypopygium pyriform, with a slender, upturned stylet projecting from its tip; dorsal lamella attached at the middle of the middle lobe, with parallel sides, supplied with long sparse bristles; left side with a large plowshaped lamella; ventral middle-piece with a large upturned hook which is spinose inwardly near apex; right side above with a small triangular plate, the apex of which is drawn out into a small finger-shaped piece that bears two long bristles at its tip. Legs rather stout; anterior tibia without spur; others each with a single one; no very distinct tibial setulæ; hind metatarsus with six transverse bands of bristles. Wings with the costa extending distinctly beyond the middle, its bristles close-set, minute, scarcely longer than the diameter of the costal vein; first and second sections of costa equal; mediastinal vein distinct; fourth vein almost straight; fifth curved at base; sixth faintly bisinuate; seventh clearly indicated, close to the anal angle. Halteres very large, with pale stalk and dark-colored knob.

There are numerous specimens of both sexes bred from larvæ in a rotting stem of paw-paw (*Carica papaya*) at East London, Cape Province, February 2, 1922.

From the descriptions above it will be evident that the bristling of the front is different in the sexes, as the female has only one bristle lateral to and just above the post-antennal group of four. I have carefully examined a large number of the minute females and am certain that none of them show more than one bristle in this position.

ANOTHER "SNOW" PHORID (DIPTERA)

By Charles T. Brues.

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Since the preparation of the note in the last issue of Psyche (Notes on Some New England Phoridæ, vol. 31, p. 44, February 1924) I have received from Mr. C. W. Johnson specimens of another species of Phoridæ taken in midwinter in Maine.

These prove to be *Trupheoneura microcephala* Loew and strangely enough the five specimens which form the series are all males. They were collected together with some other "snow" insects at Woodland, near Caribou in Northern Maine by Mr. Olaf O. Nylander on December 1, 1917. Reference to the Monthly Weather Review for November and December of that year indicates that there was no warm spell at that time, nor at any time during either month. As the maximum temperature recorded for Maine during December was 47° (at Eastport on Dec. 9) it is evident that the flies were active at a considerably lower temperature in this more northerly inland section. Moreover, the presence of males strongly suggests that the species may even breed at this time of the year. Further south the same species (including the female) has been taken in the vicinity of Washington, D. C. on January 1, January 7 and March 29, according to Malloch (Proc. U. S. Nat. Mus., vol. 43, p. 422 (1912.)

FLOWER VISITS OF INSECTS II.[1]

By Charles Robertson.

Carlinville, Illinois.

Hymenoptera (ex. bees).

The lower Hymenoptera, 26 per cent of the visitors observed, make only 16.8 per cent of the visits. Of the 437 insect flowers observed, they occur on only 43 per cent, while the bees occur on 95.4 per cent. The only respect in which they resemble the bees and show more efficiency than the flies and Lepidoptera is in the thick proboscides composed of several appendages, so that on many flowers they are more apt to transfer pollen. The flowers showing the greatest numbers of these insects are *Cicuta maculata* 145, *Sium cicutæfolium* 95, and *Pastinaca sativa* 91, with exposed nectar, and *Pycnanthemum flexuosum* 89, and *Solidago canadensis* 81, with concealed nectar.

Of the visits of the lower Hymenoptera, 95.5 per cent are to social flowers, usually with epigynous nectaries. It is held here that these insects have produced no special flowers. They resort to highly specialized social flowers which have been modified by bees. They may have had some influence in further modifying these, especially in the case of fig flowers.

The ecology of lower Hymenoptera is associated with insects on which they are parasitic or with which they provision their nests. They are therefore most abundant in summer when all except Tenthredinidæ reach their maxima. They have no

[1]The first number was published in Psyche **30**: 158-69, 1923. In the table on page 158 the local flora should be 560, with percentages as follows: Ma 27.5, Mi 28.9, Mas 17.3, Mis 21.4, Pol 4.8, Red 29.4, White 39.8, Yellow 30.7. Of the 493 indigenous flowers the percentages are: Ma 25.9, Mi 29.6, Mas 17.0, Mis 22.7, Pol 4.6, Red 29.0, White 40.3, Yellow 30.6. On page 159, line 4, for "41.6" read "about 48". In line 32 "ruby-throated" came from an abortive attempt to shorten "ruby-throated humming-bird" to "ruby-throat." On page 167, line 24, for "seventy" read "seventy-three." Besides the tables mentioned there, each one of the 1288 visitors has its visits distributed under the classes and colors as shown in **3**, 173.

relation to flowers except to visit those which suit them and are in bloom when they fly. They make fewer non-pollinating visits than any other of the general groups.

Bembicidæ.—Of 99 visits of 10 species to 49 flowers, 39.3 per cent are to Mis, 32.3 to Mas, 28.2 to Pol, 52.5 to white, 34.5 to yellow, 37.3 to Compositæ, 20.2 to Labiatæ and 13.1 to Umbelliferæ. All visits are to social flowers.

Sphecidæ.—Of 377 visits of 16 species to 110 flowers, 43.2 per cent are to Mis, 27.8 to Mas, 27.3 to Pol, 53.3 to white, 33.4 to Compositæ, 14.8 to Labiatæ and 13.5 to Umbelliferæ. Pol. shows 15.4 per cent of the flowers visited.

Scoliidæ.—Of 133 visits of 7 species to 69 flowers, 45.8 per cent are to Mis, 29.3 to Pol, 20.3 to Mas, 61.6 to white, 31.5 to Compositæ, 15.7 to Labiatæ and 12.7 to Umbelliferæ. This and the two preceding are the only families of wasps showing more than 18.7 per cent of visits under Mas.

Eumenidæ. Of 461 visits of 31 species to 109 flowers, 62.9 per cent are to Mis, 21.0 to Pol, 60.0 to white, 32.7 to yellow, 33.1 to Compositæ and 22.3 to Umbelliferæ.

Philanthidæ (including Cercerida).—Of 182 visits of 16 species to 63 flowers, 54.9 per cent are to Mis, 34.0 to Pol, 67.5 to white, 30.2 to Compositæ, 16.4 to Umbelliferæ and 12.6 to Labiatæ. Pol is 23.8 per cent of flowers visited.

Crabronidæ. Of 253 visits of 27 species to 69 flowers, 49.4 per cent are to Mis, 44.2 to Pol, 68.3 to white, 39.9 to Umbelliferæ and 26.8 to Compositæ. Pol shows 21.7 per cent of the flowers visited.

Vespidæ.—Of 182 visits of 8 species to 82 flowers, 56 per cent are to Mis, 26.3 to Pol, 59.3 to white, 39.5 to Compositæ and 13.7 to Umbelliferæ.

Chrysididæ.—Of 64 visits of 17 species to 35 flowers, 50 per cent are to Mis, 46.8 to Pol, 81.2 to white, 45.3 to Umbelliferæ and 25.0 to Compositæ. Of flowers visited, Mis shows 65.7 and Pol 31.4 per cent.

Larridæ.—Of 105 visits of 19 species to 42 flowers, 50.4 per cent are to Pol, 45.7 to Mis, 80.9 to white, 33.3 to Umbelliferæ, 20.0 to Compositæ and 16.2 to Labiatæ. Of the flowers visited, 57.1 per cent belong to Mis and 33.3 to Pol.

Tiphiidæ.—Of 19 visits of 4 species to 14 flowers, 52.6 per cent are to Pol, 42.1 to Mis, 64.4 to white, 31.5 to yellow, 78.9 to Umbelliferæ and 15.7 to Compositæ. Of flowers visited, 50 per cent belong to Mis, 42.8 to Pol and 42.8 to yellow.

Pompilidæ.—Of 188 visits of 33 species to 47 flowers, 58.5 per cent are to Pol, 36.7 to Mis, 70.7 to white, 39.3 to Umbelliferæ and 19.1 to Compositæ. Pol shows 36.1 per cent of the flowers and Mis 48.9

Nyssonidæ, Pemphredonidæ, Thynnidæ, Trypoxylonidæ, Bethylidæ, Myrmosidæ, Formicidæ male, Mutillidæ male.—Of 48 visits of 22 species to 20 flowers, 75 per cent are to Pol, 79.1 to white, 65.9 to Umbelliferæ and 10.6 to Compositæ. Pol shows 50 per cent of the flowers and Mis 40.0.

Wasps—Of 2111 visits of 210 species to 182 flowers, 49.5 per cent are to Mis, 34.4 to Pol, 63.5 to white, 30.0 to Compositæ, 24.8 to Umbelliferæ and 10.5 to Labiatæ. Of 825 visits of the Philanthidæ, Eumenidæ and Vespidæ, 59.6 per cent are to Mis. Of 677 visits of Crabronidæ and the last five groups, 51.8 per cent are to Pol. Of 574 visits before July, the wasps show 46.6 per cent to Mis, 39.3 to Pol, 54.7 to white and 37.6 to yellow, while of 1570 visits after June they show 50 per cent to Mis, 32.9 to Pol, 65.8 to white and 25.2 to yellow. The maximum shifts from A 35.1 to B' 36.7. Of the visits of Scoliidæ, Sphecidæ, Bembicidæ, Philanthidæ and Vespidæ, 13.9; of Eumenidæ, 22.3; and of Larridæ, Tiphiidæ, Pompilidæ, Crabronidæ, Nyssonidæ and Chrysididæ, 42.2 per cent are to Umbelliferæ. Of the visits of Scoliidæ, Sphecidæ, Bembicidæ, Philanthidæ and Larridæ, 15.2 per cent are to Labiatæ.

Ichneumonidæ.—Of 79 visits of 45 species to 35 flowers, 53.1 per cent are to Pol, 37.9 to Mis, 50.6 to yellow, 49.3 to white, 51.8 to Umbelliferæ and 30.3 to Compositæ. Of the flowers, 54.2 per cent are Mis, 28.5 Pol, 54.2 white and 45.7 yellow.

Braconidæ.—Of 58 visits of 33 species to 23 flowers, 51.7 per cent are to Pol, 32.7 to Mis, 58.8 to white, 41.3 to yellow, 53.3 to Umbelliferæ and 32.7 to Compositæ.

Chalcidoidea, Figitidæ, Evaniidæ.—Of 85 visits of 33 species to 25 flowers, 76.4 per cent are to Pol, 75.2 to white and 78.8 to Umbelliferæ.

Tenthredinidæ.—Of 27 visits of 14 species to 15 flowers, 59.2 per cent are to Mis, 33.3 to Pol, 70.3 to yellow, 40.7 to *Salix* and 11.1 to Umbelliferæ.

Non-aculeata.—Of 249 visits of 125 species to 62 flowers, 58.6 per cent are to Pol, 33.3 to Mis, 61.7 to white, 37.8 to yellow, 57.2 to Umbelliferæ and 20.8 to Compositæ. Before July 59.8 per cent of the visits are to yellow and 40.1 to white; after June 76.1 are to white and 23.0 to yellow. The maxima remain under A and Pol, but shift from yellow to white.

The preference is for flowers with exposed nectar and most of the visits are to them in spite of the dominance of other classes. So that *exposed nectar as a determining condition*, is limited to a few visits of the most insignificant of hymenopterous pollinators. Even then it fails except when the flowers are social. Many visitors should probably be left out, being so minute as to be of doubtful value, even if all other guests were excluded.

Lower Hymenoptera.—Of 2360 visits of 335 species to 188 flowers, 47.8 per cent are to Mis, 37.0 to Pol, 62.9 to white, 95.5 to social flowers, 29.0 to Compositæ and 28.2 to Umbelliferæ. Pol shows 11.1 per cent of the flowers visited. Of 28 non-pollinating visits 19 are to Mas and 22 to red. Visits to red are 7.5 per cent compared with 18.8 for the Alps. Ten prefer Mas, 112 Mis, 206 Pol, 240 white and 89 yellow. After June the maximum changes from A 40.6 to B' 36.7. Yellow changes from 41.5 to 25.0.

Diptera.

Midaidæ.—Two species prefer Pol and white.

Nemestrinidæ.—The single species prefers Mas and red.

Bombyliidæ.—Of 370 visits of 28 species to 160 flowers, 45.6 per cent are to Mas, 31.6 to Mis, 38.3 to yellow and 50.8 to Compositæ. Of the flowers visited, 35.0 belong to Mas and 28.1 to yellow. Visits to red are 23.7 compared with 75.0 in the Alps. After June the maxima change from Hb 27.7 to B' 66.0, Mis 31.9 to Mas 58.0, white 52.9 to yellow 43.5.

Conopidæ.—Of 238 visits of 15 species to 115 flowers, 47 per cent are to Mis, 25.6 to Mas, 20.1 to Pol, 56.3 to white, 10.9 to Labiatæ, 14.2 to Umbelliferæ and 32.3 to Compositæ. Red shows 13.8 compared with 44.4 in the Alps. After June the maximum shifts from AB 29.9 to B' 43.6. Mas changes from 14.7 to 35.9, yellow from 35.2 to 25.3 and red from 9.8 to 19.0.

Syrphidæ.—Of 1165 visits of 86 species to 203 flowers, 51.5 per cent are to Mis, 20.0 to Pol, 58.8 to white, 33.9 to yellow, 24.4 to Compositæ and 17.8 to Umbelliferæ. Red shows 7.2, in the Alps 29.3. After June the maximum changes from AB 37.8 to B' 47.5. Mi changes from 22.2 to 7.8, Mas from 2.1 to 22.9, yellow from 39.2 to 29.0.

The importance of these flies as pollinators has been greatly exaggerated. The general habit of pollen-eating is shown from the fact that the proboscis is never modified so as to prevent it. In 104 visits of Syrphidæ to diclinous flowers 31.7 per cent were to pistillate, and 68.2 to staminate, flowers. This shows pretty decisively their preference for pollen. They make more non-pollinating visits than are made by all other flies together. Of 145 visits of this kind 50.3 per cent are to Ma and 42.7 to red.

The flowers showing the greatest number of Syrphidæ are *Sassafras variifolium* 19, *Salix cordata* 22, *Solidago canadensis* 22, *Pastinaca sativa* 26, *Aster ericoides villosus* 30, *Heracleum lanatum* 32.

Empididæ.—Of 162 visits of 24 species to 87 flowers, 48.1 per cent are to Mis, 25.3 to Pol, 60.4 to white, 31.4 to yellow, 12.3 to Roasceæ, 15.4 to Compositæ and 16.0 to Umbelliferæ. Pol shows 12.6 per cent of the flowers visited. Red shows 8 per cent of the visits, in the Alps 30.1. After June the maximum changes from A 38.5 to B' 57.5. The siphonate proboscis was

evidently developed as a predaceous organ, but is also used for sucking nectar. *Parempis clausa* is evidently exclusively anthophilous. It flies 113 days after all of the other species have disappeared. Being 4 per cent of the species, it makes 27 per cent of the visits.

Stratiomyidæ.—Of 53 visits of 13 species to 36 flowers, 45.2 per cent are to Mis, 43.3 to Pol, 60.3 to white, 35.8 to yellow and 41.5 to Umbelliferæ. Red shows 3.7, in the Alps 40.0.

Tachinidæ.—Of 842 visits of 108 species to 158 flowers, 53.4 per cent are to Mis, 29.8 to Pol, 66.5 to white, 25.2 to Umbelliferæ and 33.9 to Compositæ. After June the maximum shifts from A 37.5 to B' 46.3. White changes from 59.3 to 70.1 and yellow from 37.5 to 26.0.

Other Calyptratæ.—Of 692 visits of 50 species to 140 flowers 48.2 per cent are to Mis, 29.6 to Pol and 64.5 to white.

Of total Calyptratæ visits, 23 per cent are to Umbelliferæ and 25.5 to Compositæ.

Acalyptratæ.—Of 178 visits of 53 species to 59 flowers, 47.1 per cent are to Pol, 43.8 to Mis, 55.0 to white, 43.8 to yellow, 58.4 to Umbelliferæ and 12.3 to Compositæ.

Muscoidea.—Of 1712 visits of 211 species to 191 flowers, 50.3 per cent are to Mis, 31.6 to Pol, 64.3 to white, 31.7 to yellow, 26.6 to Umbelliferæ and 28.3 to Compositæ. Pol is 12 per cent of flowers visited. Red shows 3.9 per cent of the visits, to 14.1 in the Alps. They are probably more important to flowers than the Syrphidæ, since they are usually after nectar. Of the total fly visits 45.3 per cent are made by Muscoidea and 30.8 by Syrphidæ.

Tabanidæ, Scenopinidæ, Pipunculidæ, Leptidæ, Phoridæ.—Of 18 visits of 9 species to 13 flowers, 77.7 per cent are to Pol, 72.2 to white and 72.2 to Umbelliferæ.

Nematocera.—Of 44 visits of 15 species to 24 flowers, 50 per cent are to Pol, 56.8 to white, 43.1 to yellow and 50.0 to Umbelliferæ. These flies are usually associated with more

efficient pollinators and often are so small that they can get the nectar without much probability of touching the anthers and stigmas.

Diptera.—Of 3775 visits of 403 species to 266 flowers, 48 per cent are to Mis, 25.4 to Pol, 59.3 to white, 32.9 to yellow, 21.8 to Umbelliferæ and 28.2 to Compositæ. Mis shows 31.9 per cent of the flowers, Pol 8.6 and white 46.9. One prefers Ma, six prefer Mi, 21 Mas, 158 Pol, 192 Mis, 9 red, 133 yellow, 253 white. Visits to red are 7.7, Alps 22.2, Low Germany 24.2. Berlin Garden 33.1. After June the maximum changes from A 35.4 to B' 48.1. Yellow changes from 37.7 to 28.3. Of 256 non-pollinating visits, 32.8 are to Ma, 21.0 to Mas, 17.0 to Pol and 38.6 to red.

Next to bees, flies visit more species of flowers and make more visits than any other anthophilous insects. Being 31.2 per cent of the species, they make 27 per cent of the visits, 36.8 per cent of the total visits to Pol. The total number of flowers visited is less than that for Bombidæ or Halictidæ. The flowers visited by 62 or more flies are *Solidago canadensis* 62, *Zizia aurea* 63, *Sium cicutæfolium* 71, *Cicuta maculata* 82, *Pastinaca sativa* 113, *Heracleum lanatum* 121, *Aster ericoides villosus* 121. The flowers showing the greatest number of siphonate flies are *Solidago canadensis* 16, *Boltonia asteroides* 18, *Bidens aristosa* 21, *Pycnanthemum flexuosum* 22, *Eryngium yuccifolium* 23 and *Aster ericoides villosus* 31.

The importance of flies as pollinators is greatly exaggerated. They are apt to show as the exclusive visitors in unfavorable weather, or in localities where the flora and insect fauna have been greatly disturbed. The proboscis is usually rather thick so that the pollen readily touches and adheres to it, but the more highly specialized for probing flowers it becomes, the less likely it is to extract the pollen. In the lists have been admitted flies which should probably be excluded on account of their small size, or ability to extract nectar or eat pollen without effecting pollination.

Some flies have taken possession of some non-social flowers which have become adapted to flesh-flies or minute flies. The flowers which the Diptera prefer, however, are highly specialized social flowers, usually with epigynous nectaries, 86.3 per cent of the visits being to social flowers.

Lepidoptera.

Sphingidæ.—Of 22 visits of 7 species to 15 flowers, 54.5 per cent are to Ma, 40.9 to Mas, 63.6 to red, 45.4 to Polemoniales and 13.6 to Labiatæ. In the Alps visits to red are 63.2.

Other Heterocera.—Of 106 visits of 21 species to 68 flowers, 47.1 per cent are to Mis, 31.1 to Mas, 10.3 to Pol, 48.1 to white, 34.9 to yellow and 57.5 to Compositæ. Red shows 16.9, in the Alps 58.6.

Rhopalocera.—Of 1065 visits of 67 species to 203 flowers, 43.6 per cent are to Mas, 24.3 to Mis, 38.3 to red, 11.0 to Labiatæ and 36.3 to Compositæ. In the Alps red shows 55.2.

Lepidoptera.—Of 1193 visits of 95 species to 211 flowers, 42.4 per cent are to Mas, 25.9 to Mis, 39.3 to white, 36.8 to red. In the Alps red shows 56.1, Berlin Garden 64.0, Low Germany 70.2. One prefers Mi, 7 Ma, 12 Pol, 22 Mis, 51 Mas, 46 red, 33 white, 16 yellow. Of 175 non-pollinating visits, 52.5 per cent are to Ma, 34.2 to Mas and 57.1 to red. Before July they prefer Mas and red; after June, Mas, Mis, Pol, white and red. The maximum changes from Hb 32.6 to B' 50.1. Visits to non-social flowers change from 48.2 to 7.2.

The structure of the proboscis seems to indicate that the butterflies not only had little, or nothing, to do with the origin of insect flowers but that they did not come into existence until after the highly specialized bee flowers had been developed. The moths are important visitors of few flowers and have influenced the development of few, except in the case of the Sphingidæ. Butterflies are large and correspond little with the variable sizes of flowers. Their proboscides average long, so that they are usually able to reach the nectar of the deepest bee flowers. Their relations to flowers are often that of nectar

thieves. The proboscis is exceedingly slender, smooth and dry so that it often does not touch the pollen, or does not readily hold it. On flowers with exserted anthers and stigmas the butterflies are probably the most useful. But even in such cases they often insert their tongues into flowers whose anthers and stigmas they do not touch with their bodies. It is a regular thing for them to visit personate and papilionaceous flowers without any likelihood of touching the anthers. In slender tubed flowers with included anthers they may touch the anthers, but even here there is doubt about much pollen sticking to their tongues. There are probably no slender-tubed butterfly flowers from which bees are excluded and in which bees are not likely to be more useful. A bee's proboscis has from five to seven appendages wet with nectar or honey, and which get so covered with pollen that in mounting it is often necessary to wash the pollen out.

In the percentage of visits, 8.5, over species, 7.3, the Lepidoptera show a slight gain, but in 41 flowers whose visitors were taken as they came they lost in percentage of individuals.

Other Visitors.

Coleoptera.—Of 438 visits of 137 species to 113 flowers, 42.4 per cent are to Mis, 40.8 to Pol, 64.8 to white, 15.2 to Compositæ and 39.4 to Umbelliferæ. One prefers Mas, 48 Mis, 81 Pol, 46 yellow and 88 white. Visits to red are 5.2, in the Berlin Garden 16.9, Low Germany 18.3, Alps 23.2. Of 123 non-pollinating visits, 34.9 per cent are to Mis, 30.0 to Mas and 40.6 to yellow. After June the maximum changes from A 50.9 to B' 46.2.

The flowers showing the greatest number of beetles are *Pastinaca sativa* 42, *Aruncus sylvester* 33, *Cryptotænia canadensis* 19, *Sium cicutæfolium* 19.

Beetles seem to have developed anthophilous habits as a secondary matter, and were probably few on primitive flowers. Some have structures fitting them for obtaining nectar, as

Chauliognathus pennsylvanicus, which has maxillary lobes extensile by 4 or 5 mm, and makes more visits than any other beetle.

Beetles probably have produced no special flowers. They principally resort to social flowers with epigynous nectaries.

Hemiptera.—Of 113 visits of 21 species to 64 flowers, 47.7 per cent are to Mis, 30.9 to Pol, 52.2 to white, 38.0 to yellow, 34.5 to Compositæ and 30.9 to Umbelliferæ. Ten prefer Mis, eight Pol, 11 white and ten yellow. After June yellow changes from 47.1 to 29.0. The maximum shifts from B 39.6 to B' 50.0. The proboscis, though not developed for flower visits, is sometimes used to extract nectar.

The Hemiptera and Coleoptera form 12.2 per cent of the visitors observed, but make only 3.9 per cent of the visits.

Neuroptera.—Chrysopa plorabunda, found on some Umbelliferæ with exposed nectar, is not included in the tables.

Birds.—Of 29 visits made by the rubythroat, 82.7 per cent are to Ma, 55.1 to red, 17.2 to Personales, 13.7 to Labiatæ, 13.7 to Leguminosæ, 10.3 to Polemoniales. It picks out the most highly modified and brightest colored of the long-tongued bee flowers. The bird flowers belong to melittophilous groups and have been appropriated by the humming-birds.

Total Visitors.—Of 13971 visits made by 1288 visitors to 437 flowers, 39.8 per cent are to Mis, 20.4 to Mas, 18.7 to Pol, 51.3 to white, 31.7 to yellow, 28.9 to Compositæ and 15.9 to Umbelliferæ. Thirty-six prefer Mi, 44 Ma, 176 Mas, 471 Pol, 511 Mis, 126 red, 390 yellow and 755 white. After June visits to Mas change from 8.3 to 32.7, to yellow from 34.2 to 29.9, and the maximum changes from AB 26.8 to B' 44.6. Visits to red are 16.8 per cent, in the Alps 41.6.

Insects and Their Importance to Flowers.

Loew's Groups.—If the flower classes A, AB and Po are designated as allotropic, B and B' as hemitropic, and Hb, F and O as eutropic, and the insects are classed according to the kinds

of flowers which they visit, it will be found that those which before July are eutropic, hemitropic or allotropic, are hemitropic after June. Really the highest specialized and latest developed flowers and insects are hemitropic.

Specialization for obtaining Nectar.—The rubythroat, the Lepidoptera, long-tongued bees and some siphonate flies can visit a great many flowers from which short-tongued bees are excluded. They are at some disadvantage on flowers with shallow nectar.

Müller (**3**,58) states that *Apis* and *Bombus* play by far the most important part in the fertilization of German indigenous flowers. Knuth (**2**,154) says: "Just as the pollen-collecting apparatus has reached its highest degree of development in *Apis* and *Bombus*, so also has the mouth of the bees become best adapted for rifling the nectar of flowers. It is therefore intelligible that bees belonging to these two genera play a far more important part than any other insects in the pollination of our indigenous flowers." When these bees are compared with other bees having a similar flight, the importance of the specialization of the proboscis and scopa is not so obvious. When 40 species of Halictidæ make nearly as many visits as 133 species of long-tongued bees, it is not on account of a more highly specialized tongue or scopa. The Halictidœ visit 14 more flowers and make 1123 more visits than the Bombinæ, 927 more than Bombinæ and *Apis* together. When *Apis* and *Bombus* make only 13.3 per cent of the visits recorded in Müller's *Fertilisation of flowers*, it is not easy to understand these statements regarding their importance in pollination.

Dependence on a Floral Diet.—The food of bees is almost exclusively from flowers. The fig chalcids and *Pronuba* are about the only insects which can compare with them. The importance to flowers of the nest-provisioning habit is shown by the fact that the nest-making bees average 23.4 visits, while the inquilines average 10.7. The females of the nest-makers average 20.6 visits, while the males average 10.3. The females of the inquilines average 8.8 and the males 8.0.

Number of Species.—On account of having more species, and in spite of a lower average number of visits, the flies and lower Hymenoptera surpass the Lepidoptera; the Halictidæ and Megachilidæ surpass the Bombidæ; the Andrenidæ surpass the Euceridæ; the Muscoidea surpass the Syrphidæ; the Syrphidæ and Bombyliidæ surpass the Conopidæ; the Eumenidæ surpass the Sphecidæ, Vespidæ and Scoliidæ; the Crabronidæ and Pompilidæ surpass the Vespidæ, Philanthidæ, Scoliidæ and Bembicidæ.

Average Number of Visits.—In spite of the fewer species, the bees surpass the flies in average number of visits. The Bombinæ surpass the Euceridæ, Megachilini, Nomadidæ, Osmiini or Epeolidæ which have more species. The Halictidæ make 1366 more visits than the Andrenidæ, although they have only five more species.

Length of Flight.—The high average for *Apis mellifera*, Bombinæ, Ceratinidæ, Halictidæ and Vespidæ is associated with the long flight, the most important condition determining the visits of bees. Bees flying all season are 23.3 per cent of the species and make 51.2 per cent of the bee visits.

Abundance.—Mere commonness is an important condition in determining the visits to flowers. Insects visiting 11 or more flowers are 27.1 per cent of the species and make 77.6 per cent of the visits. The bees, rubythroat and Lepidoptera are the only visitors which gain in percentage of visits over species. Bees gain in percentage of individuals over visits and all other insects lose.

The following insect groups make more than 139.7 visits, one per cent of the total:

Bees 6063 long-tongued 3061 short-tongued 3002.—Halictidæ 1951, Megachilidæ 786, Bombidæ 764, Andrenidæ 585, Euceridæ 521, Nomadidæ 272, Epeolidæ 198, Ceratinidæ 194, Prosopididæ 166, Panurgidæ 141, Colletidæ 140.

Flies 3775.—Muscoidea 1712, Syrphidæ 1165, Bombyliidæ 370, Conopidæ 238, Empididæ 162.

Lower Hymenoptera 2360, aculeate 2111, non-aculeate 249.—Eumenidæ 461, Sphecidæ 377, Crabronidæ 253, Pompilidæ 188, Vespidæ 182, Philanthidæ 182.

Lepidoptera 1195.—Rhopalocera 1065, Papilionidæ 324, Nymphalidæ 312, Hesperidæ 305.

Coleoptera 438.

Phenology of Anthophilous Insects.

Bees.

With a few exceptions bees are the only flower-visiting insects which are phenologically associated with flowers. Their presence implies the necessary presence of flowers. The composition of the bee fauna for the season or for particular parts of the season is determined by the presence of certain kinds of flowers.

Dasygastræ.

The bees forming the superfamily Trypetoidea differ decidedly from the long-tongued bees in general in forming an earlier maximum. They fly from March 21 to October 22 and have a maximum of 64.5 per cent July 4, 85.4 per cent flying in June. The Stelididæ, May 9—October 18, have a maximum of 83.3 per cent on June 14. The Megachilidæ, March 21—October 22, have a maximum of 69 per cent July 4, 85.7 per cent flying in June. The Osmiinæ, March 21—October 18, have a maximum of 75 per cent June 16, 90 per cent flying in June. The Megachilinæ, May 11—October 22, have a maximum of 95.4 per cent July 4.

Scopulipedes.

Apygidialia.—The Colletoidea, March 20—October 30, with a maximum of 54.1 per cent May 29-31, show 62.5 per cent flying in June. The Prosopididæ, April 20—October 11,

show a maximum of 88.8 per cent May 15—June 9. The Colletidæ, March 20—October 30, show a maximum of 46.6 per cent June 21, 53.3 per cent flying in July and August.

The Ceratinoidea are represented by two Ceratinidæ, March—November ,and one of the Xylocopidæ, May 5—July 5.

The Apoidea, represented by Bombidæ and Apidæ, fly from March to November, with all, except one rare species, flying simultaneously June 22-28. The Bombidæ fly from March 15 to November 4. The females appear in March and April, the workers May—July, and the males in July and August. As far as pollination is concerned the maximum of the group is in August.

Pygidialia.—The Dasygastræ and Apygidialia form old and fragmentary groups characterized by distinct structural marks and by discontinuous geographical distribution. Together they make only 28.8 per cent of the indigenous bees. On the other hand the Pygidialia are 71.1 per cent of the species. They are more recent, more plastic, less distinctly separated into groups and of a more continuous geographical distribution.

The Halictoidea, March 17 to November, have a maximum of 91.3 per cent June 14-15, 93.1 per cent flying in June. The Halictidæ, March 17 to November, have a maximum of 94.6 per cent on June 14-15. Nineteen species have been observed in March and 21 in November. Some are so rare that their flight has not been made out, but it is likely that all are flying simultaneously from June until October. The Dufoureidæ are represented by *Halictoides marginatus*, August 27—October 3. The Nomiidæ are represented by *Paranomia nortonii*, June 26—September 9.

The Andrenoidea fly from March 17 to October 30, and have a maximum of 45.5 per cent May 11-13, 57.3 per cent flying in May. The percentage declines to 19.1 in July and rises again to 32.3 in August and September. The Andrenidæ, March 17—October 30, have a maximum of 60.7 per cent May 11-13, 70.5 per cent flying in May. Only one species is flying July 30—August 12, while six are flying simultaneously September 8-20.

All of the late ones are oligoleges of Compositæ and 44.4 per cent of the early ones are oligoleges of various flowers. *Andrena* and *Pterandrena*, a genus of Compositæ oligoleges, are both separated into early and late groups. The Panurgidæ have the most definite position of any of the dominant families of bees, May 28—October 29, all of them together August 30—September 3, 87.5 per cent being oligoleges. Of the oligoleges 78.5 per cent affect Compositæ. The Macropididæ are represented by *Macropis steironematis*, June 12—July 18.

The Anthophoroidea fly from April 8 to October 22, with a maximum of 58.9 per cent August 8-26, 66.6 per cent flying in July. The Euceridæ, April 8 –October 22, have a maximum of 62.5 per cent August 8-28, 68.7 per cent flying in August. *Tetralonia* has a May maximum. All of the other Euceridæ complete their flight between June 13 and October 22, 76.9 per cent being simultaneous in August. Here the polyleges, oligoleges of Compositæ and other oligoleges have a very definite and similar position. The Anthophoridæ fly from April 8 to September 20. The Emphoridæ fly from June 24 to October 7.

Short-tongued Bees.—These fly from March 17 to November, and have a maximum of 58.6 May 18-31, 72.7 per cent flying in May.

Long-tongued Bees.—These fly from March 15 to November, and have a maximum of 48.6 per cent, July 13, 66.1 per cent flying in August.

Bees, Total.—These fly from March 15 to November and have a maximum of 47.2 per cent July 13.

Oligoleges.—That the oligolectic bees are associated in their time of flight with the blooming seasons of the flowers on which they depend is as evident as that the inquiline bees are phenologically associated with their hosts, or that other insects are associated with the time of the insects on which they are parasitic, or with the presence of the food on which their larvæ feed. This is more evident than the converse proposition that the blooming times are correlated with the flight of the oligoleges, for usually the flowers have other visitors which can effectually

pollinate them. Sometimes the oligolege is of no particular use to the flower, so that the relation is quite one-sided. Usually the blooming season of a plant may be explained by the simple statement that it agrees with its relatives, all of which bloom about the same time.

The same statement, however, is true of the oligoleges. They resemble their relatives in time even more than the plants on which they depend. Evidently the groups to which the oligoleges belong were originally quite definitely located phenologically so that their members were in close competition, to avoid which there arose a diversification of food habits, some of the species becoming oligolectic and the others remaining polylectic. In some groups, however, the phenologically correlated relatives were oligoleges of related plants, like *Melissodes* and Compositæ. Here the diversification in food habits resulted in some of the species becoming polylectic. The food habits have evidently tended to restrict the oligoleges to the time of their food plants and to give the polyleges more latitude in the extension of the time. Consequently the flight of the oligoleges averages shorter than that of their related polyleges.

Inquilines.—The inquiline bees are phenologically associated with their hosts and have no direct relation to flowers. They visit the flowers most convenient to them. The Nomadidæ, inquilines of Andrenidæ, show evidences of having shortened their proboscides to suit the kinds of flowers which were most common where they were flying. Although they are long-tongued bees, their flower visits resemble those of their short-tongued hosts almost exactly.

Coelioxys consists of inquilines of Megachilini and the seasons are similar. *Psithyrus*, an inquiline of *Bombus*, has a similar flight.

The Sphecodinæ are evidently inquilines of other Halictidæ. With the exception of *Proteraner*, they resemble the other Halictidæ in the fact that the females appear first and the males later and that they fly all season. The same applies to *Paralictus*, which evidently consists of inquilines of *Chloralictus*.

Among the Nomadidæ, some species of *Holonomada* may be inquilines of *Tetralonia* and *Melissodes*. In the Pasitidæ, *Holcopasites* is probably an inquiline of Panurgidæ. Of the Melectidæ *Bombomelecta thoracica* is evidently an inquiline of *Anthophora ursina* and *Melecta interrupta* of *Amegilla walshii*.

In the flight of the inquilines there is a marked correlation which often seems to determine the time. Thus *Alcidamea simplex* flies 85 days while its inquiline, *Microstelis lateralis*, flies 43 days. *Neotrypetes productus* flies 144 days while its inquiline, *Stelidium trypetinum*, flies 135 days.

But the phenological position is usually quite inveterate and hereditary, for the inquilines are usually related to their hosts. Ten species of *Triepeolus* are evidently mainly inquilines of Euceridæ. They fly from June 27 to October 21 while the Euceridæ fly from April 8 to October 22. Consequently *Triepeolus* only infests the late Euceridæ. So phenologically the species resemble their relatives more than they do the Euceridæ. One infests *Melitoma taurea*, one of the Emphoridæ. So it seems the genus is more apt to infest an unrelated host flying at the same time than it is to change time to follow the Euceridæ. Some of the early Euceridæ may be infested by *Holonomada*. *Colletes* flies from March 20 to October 30. Their inquilines, *Epeolus*, fly from May 29 to October 23. So there is at least one *Colletes* not infested by *Epeolus*, *C. inæqualis*, possibly infested by some *Nomada*. So that phenologically the Epeolidæ resemble one another more than they do the groups on which they are inquiline.

As in the case of oligoleges, the conclusion is reached that the phenological position is the oldest, most inveterate, and the inquiline habit later and determined by, rather than determining, the phenological position.

Other Visitors.

Lepidoptera.—The presence and time of flight of the Lepidoptera is determined by the occurence of their food plants. Usually they fly a long time and have more than one brood.

Naturally they occur throughout the flower-blooming season and are most abundant in summer when the most of plants are in vegetation. The butterflies form a long low curve, March 10—November 7, and have a maximum of 80.5 per cent July 7-22, 87 per cent flying in July. *Pronuba* is perhaps the only lepidopter whose season is correlated with, and indicates the presence of, particular kinds of flowers. Butterflies often have food plants which are not entomophilous. Given their food plants and long-tongued bee flowers, they could get along pretty well.

Diptera.—The Diptera fly from March 9 to November 6 and show a maximum of 59.2 per cent July 22-27, 67 per cent flying in June. The Nematocera, April 6—October 18, have a maximum of 50 per cent May 25—June 2, 90 per cent flying in May. The Stratiomyidæ, April 21—August 26, have a maximum of 70 per cent May 18-22, 80 per cent flying in May. The Empididæ, April 10—October 8, have a maximum of 72.2 per cent April 30—May 4, 88.8 per cent flying in May. The Syrphidæ, March 10—November 6, have a maximum of 67.5 per cent June 10-11, 80 per cent flying in May. The maximum of the lower Syrphidæ is May 12-15, while that of the higher is June 10-11. The Muscoidea, March 9—November 6, show a maximum of 69.2 per cent July 26-27. They are 51.6 per cent of the Diptera observed on flowers. The Bombyliidæ, March 21—October 29, have a maximum of 60.7 per cent August 21, 67.8 per cent flying in August. The Conopidæ, April 10—November 3, have a maximum of 76.9 per cent July 4—August 8, 84.6 per cent flying in August.

The flight of Diptera is evidently associated with that of the insects on which they are parasitic, or the presence of the plants, or other food, on which the larvæ feed. None have a primary relation to flowers. Their adaptations to flowers are only to such flowers as happened to be present during their flight. Not more than 18 per cent have siphonate proboscides.

Hymenoptera (ex. bees).—The lower Aculeata fly from March to November and have a maximum of 86.8 per cent July 25-27, 91.7 per cent flying in July and 90.6 per cent in

August. The total lower Hymenoptera have a maximum of 74.5 per cent July 22-27, 80 per cent flying in July and August. They are phenologically associated with their food plants or with the insects upon which they are parasitic or with which they provision their nests. Only the fig chalcids have an important relation to any flower.

Coleoptera.—The Coleoptera, March 21—November 6 have a maximum of 52.6 per cent June 9, 53.1 per cent flying in June.

Hemiptera.—The Hemiptera, April 7—October 23, have a maximum of 68.4 per cent June 28—July 8, 78.9 per cent flying in June.

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ON THE GENUS HALOBATES FROM JAPANESE AND FORMOSAN COASTS (HEMIPTERA: GERRIDÆ).

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Of that well known pelagic genus of Hemiptera, *Halobates*, only two species have hitherto been recorded from the seas adjacent to Japanese islands. Recently, four more species, all apparently new, have come under my observation, thus giving in all six species to the Halobates-fauna of the same region.

Before describing these new species, it may be pointed out that the hind tarsus of this genus is two-jointed, instead of being one-jointed. The alleged one-jointedness of the hind tarsus has been considered as an important generic character of *Halobates* by many entomologists, except Dahl, who states that "Die Tarsen sind ebenfalls zweigliedrig" (Plank. Exped., Humboldt-Stiftung, Bd. 2, p. 2, 1893). The hind tarsi of all the species studied by me are two-jointed, as in all the other genera of the Family Gerridæ. This point is often difficult to make out, because of the fact that the joints are extremely slender and pubescent. In newly moulted specimens, however, the two-jointedness is readily recognizable.

Halobates apicalis sp. nov. (Fig. A).

Body ashy gray. Head pale yellowish brown, with a prominent longitudinal fascia on the vertex; frons with a black spot which is sometimes confluent with the fascia on the vertex. Eye moderately projected laterally, dark brown. Antenna with two basal joints pale yellowish brown and two apical joints black; first joint longer and thicker than others, with two blackish brown lines beneath; second joint about two-thirds as long as the first; fourth joint slightly shorter than the second, tapering toward the apex; jointlet between second and third joints pale

yellowish brown, same between third and fourth joints black and much shorter than the former. Rostrum passing the anterior coxa, pale yellowish brown; apex of labrum of the same color; the line on the under surface of third and fourth joints entirely black. Pronotum pale yellowish brown with two large spots reaching the anterior margin, which is sinuate; posterior margin moderately so. Meso-and metanotum black with pale yellowish brown lateral sides; the central portion somewhat paler in the male; sternum pale yellowish brown, thickly pubescent. Anterior leg pale yellow; coxa and trochanter very short, the latter with an acute, apical bifurcate spine; femur thick especially so in the male, angularly projected interiorly at the base, inner surface black with minute and delicate dentation; tibia a little shorter than femur, with a distinct spine at the apex, blackish at the tip and on the inner surface; first tarsal joint very short, somewhat spherical in shape; second joint very long, about five times as long as the first, with the apical two-thirds black; claws brown, arising near the base of the second joint. Intermediate leg pale yellowish brown, with the inner margin of trochanter, outer margin and apex of femur, tibia and tarsus dark brown; tibia a little shorter and much thinner than femur, with a fringe of long hairs interiorly, except the basal one-fourth of the length; tarsus two-jointed, first joint a little longer than twice the length of the second, but not furnished with the fringe of hairs which is found in all other species of the genus, second joint with small claws near the apex. Posterior leg much shorter than the intermediate one, pale yellowish brown, with the apex of femur, of tibia and of tarsus dark brown; first tarsal joint about half the length of the second, which is furnished with small claws near the base. Abdomen black above, pale yellowish brown or pale grayish yellow below; sixth segment black with pale yellowish brown anterior margin, about as long as three preceding segments taken together. First male genital segment pale yellowish brown with somewhat greenish horn-like lateral processes beneath; second segment black above with brown posterior margin, pale yellowish brown below.

Female genital segments pale yellowish brown, posterior margin of the penultimate segment and the whole of the last segment black above.

Length of body; ♂3 mm., ♀ 3.5 mm.

Holotype, ♂, allotopotype, ♀, and many paratopotypes; Ampin near Tainan, South Formosa, Sept. 9, 1921, (Teiso Esaki).

This species is one of the smallest in the genus and is most readily distinguished from other species by the characteristic markings of the head, and by the absence of the fringe of long hairs on the first intermediate tarsal joint. It is somewhat allied to the species of the Genus *Metrocoris* in respect to the structure of anterior femur and tarsus, but the presence of the fringe of long hairs on the intermediate tibia, coloration and general aspect, as well as the marine habitat, make the species more rationally referable to *Halobates* than to *Metrocoris*.

This species is found on a small stream of salt water connecting a pond to the sea, and a large number of specimens swarm in a shaded surface of the stream.

Halobates shiranui sp. nov. (Fig. C).

Body ashy gray, short and broad. Head black with brown pubescence on lateral sides, vertex without markings; eye brown. Antenna black, first joint about as long as the third and fourth joints put together, third and fourth joints nearly equal in length. Rostrum black, reaching the anterior coxa. Pronotum black, anterior margin moderately sinuate, posterior margin very slightly so, distinct transverse impression at the middle of pronotum. Meso- and metanotum together almost as long as broad, swollen and black. Anterior leg black with brown coxa and trochanter; tibia nearly as long as femur; first tarsal joint joint very short, almost as long as thick, about one-fifth the length of the second joint; claws arising at the middle of the second joint. Intermediate and posterior legs black, femora tapering toward the apex; intermediate tibia a little shorter than femur; first tarsal joint about twice the length of the second;

posterior tibia nearly half as long as femur, tarsus about one-fourth as long as tibia. Abdomen black above, pale brown beneath.

Length of body: 4 mm.

Holotype, ♀, Masaru, near Saseho, Province of Hizen, Japan, on the coast of East China Sea, June 11, 1922 (Mr. Yanagiwara). Type in my collection.

The nearest ally of this species is *Halobates apicalis* n. sp., which is much smaller. These two species are separated from the rest of the genus in having very short first tarsal joint.

Halobates japonicus sp. nov. (Fig. B).

Body black, slightly suffused with ashy gray. Head black with two oblique brown spots near the posterior margin; eye moderately projected, brownish. Antenna black with the apex of the last joint brownish, not longer than the body, first joint subequal in length to the other three joints put together, second and fourth joints nearly equal, third joint much shorter than others. Rostrum black scarcely passing the anterior coxa. Pronotum black, moderately sinuate along anterior and posterior margins, somewhat elevated at the center. Meso- and metanotum black, moderately convex. Prosternum pale brown. Anterior leg black, coxa blackish brown, with pale brown apex; trochanter blackish brown, paler toward apex and base, with a small black spine at the apex; femur very thick in the male; tibia black with the inner surface more or less brownish, shorter than femur, the apical spine angular but not sharply pointed; tarsus black with the first joint shorter than the second, which is furnished with claws near the base. Intermediate and posterior legs black, femora gradually tapering toward the apex; tibiæ much shorter and thinner than femora. Intermediate tibia about two-thirds the length of femur, furnished with a fringe of long hairs along the apical two-thirds; first intermediate tarsal joint almost three times as long as the second, with a similar fringe of hairs. First posterior tarsal joint about three-fifth as long as the second, the latter with claws at the middle. Abdomen black, more or

less suffused with brown. The first male genital segment black above with the lateral and posterior portions yellowish brown, dark brown beneath; the horn-like processes slender and very dark in color; second segment yellowish brown beneath.

Length of body: ♂ 5 mm., ♀ 5 mm.

Holotype, ♂, allotopotype, ♂, and paratopotypes: Aburatsubo creek near Misaki, Province of Sagami, Japan, July, 1921 (Teiso Esaki). Paratypes: the coast of the Province of Kii (Mr. Takeuchi), the coast of the Province of Tosa (Mr. Takenouchi). Types in my collection.

This species is found rapidly striding on calm water close to the shore near the head of Aburatsubo creek. A few probable examples of this species were observed by me on the Kagoshima Bay, the southernmost portion of Japan proper.

Although resembling *Halobates germanus* White, this species differs from it in its blackish coloration, much larger size, and in the structure of antenna.

Halobates germanus White.

Halobates germanus White, Chall. Rep., Zool., vol. 7, pt. 9, p. 50, pl. 1, fig. 6, 1883. Dahl, Plank, Exp., vol. 2, p. 7, 1893.

Distant, Fauna Brit. Ind., Rhyn., vol. 5, p. 152, 1910.

This species has hitherto been recorded from the following localities: "Celebes Sea," "between the Admiralty Islands and Japan," "Mare della China" (After White), "Andeman Sea" (After Distant). I have not yet found this species near either Japan or Formosa, but have in my collection four specimens of it from Papan, Johore, Malay Peninsula (Mr. Fukushima).

Halobates sericeus Eschscoltz.

Halobates sericeus Eschscholtz, Emtomogr., vol. i, p. 108, 1822. Burmeister, Handb. Entom., vol. 2, p. 209, 1835. Amyot et Serville, Hem., p. 412, 1843. White, Chall. Rep. Zool., vol. 7, pt. 19, p. 47, 1883. Dahl, Plank. Exp., vol. 2, p. 7, 1893.

Oshanin, Verz. Palæ. Hem., vol. I, p. 500, 1908. Van Duzee, Cat. Amer. Hem., p. 432, 1917. Hungerford, Bull. Univ. Kansas, vol. 21, p. 116, 1919.

This species is widely distributed over the Pacific and Atlantic Oceans, and I have examined two specimens from Hawaii, kindly presented to me by Dr. S. Isshiki. Habita: "Many stations on the voyage from the Admiralty Islands to Japan, and from Japan to Honolulu" (White). Oshanin states that "In parte occidentali intertropicali oceani Pacifici, sub. 38 lat. bor. in vicinitate Japoniæ quoque investa species."

Halobates matsumurai sp. nov. (Fig. D).

Halobates sericeus Matsumura (nec Eschscholtz), Thaus. Ins. Japan, Addit., vol. I, p. 27, pl. II, fig. 8, 1913.

Body ashy gray, very sericeus. Head with two brown oblique spots at the posterior margin; eye moderately projected, black. Antenna black with the apical half of the fourth joint brownish, not longer than the body, first joint nearly as long as the remaining three joints put together, second and fourth joints nearly equal in length, third joint shortest. Rostrum shiny black, reaching anterior coxa. Pronotum with moderately sinuate anterior and posterior margins. Anterior leg black; coxa, trochanter, and, in the female, the base of femur pale yellowish brown; femur very incrassate in the male; the apical projection of tibia somewhat acute; first tarsal joint much longer than the second, which is about two-thirds the length of the first and with claws near the base. Intermediate tibia about two-thirds the length of and much thinner than femur; first tarsal joint about four times as long as the second. Posterior tibia about half the length of femur; tarsus one-third of tibia, with the first joint shorter than the second. Body pale yellowish brown beneath. The first male genital segment black above with lateral and posterior portions brown; pale brown or gray beneath; the horn-like processes very slender and black; second segment pale brown beneath.

Length of body: ♂ 5 mm., ♀ 5.5 mm.

Holotype, ♂, allotopotype, ♀, and paratopotypes: the coast of Tansui, near Taihoku, Northern Formosa, Sept. 27, 1921 (Teiso Esaki). Paratypes: Takasago, Province of Harima, coast of the Inland Sea of Japan (Prof. S. Matsumura); Shimabara, Province of Hizen, coast of East China Sea (Mr. Yamasaki). Types in my collection.

This species is somewhat allied to *Halobates germanus* White but is much larger in size, more elongated, especially in the female, and has the first anterior tarsal joint much longer than the second.

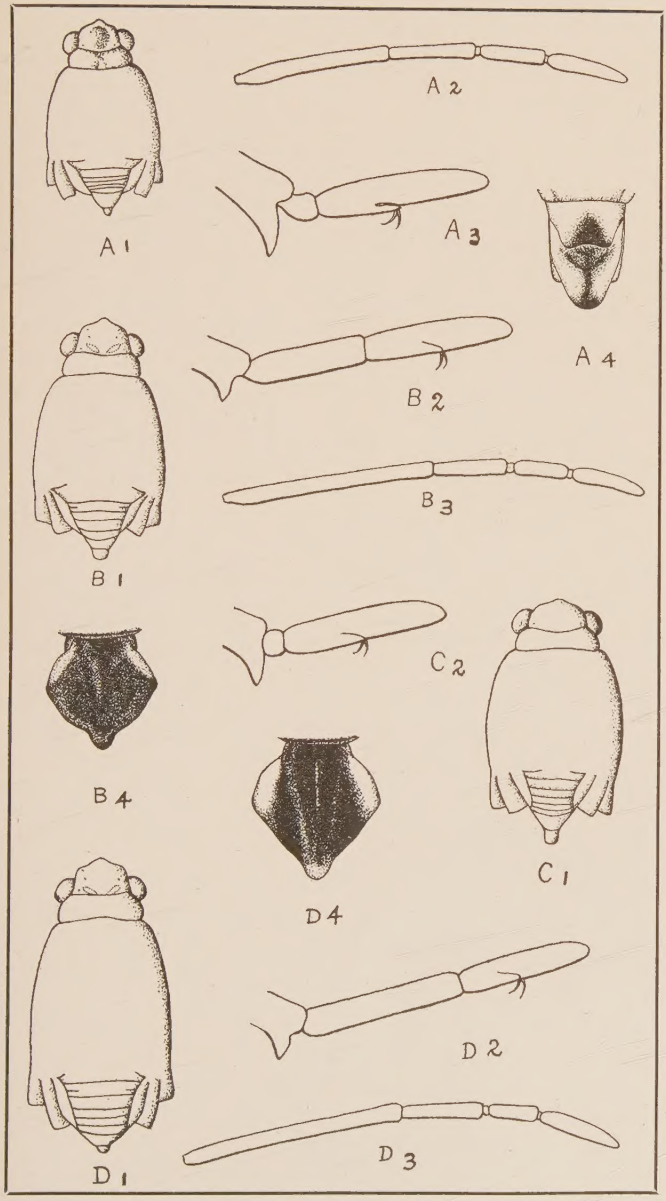
Explanation of Plate V.

A1, *Halobates apicalis* n. sp. A2, antenna. A3, Anterior tarsus A4, Male genital segments, dorsal view.

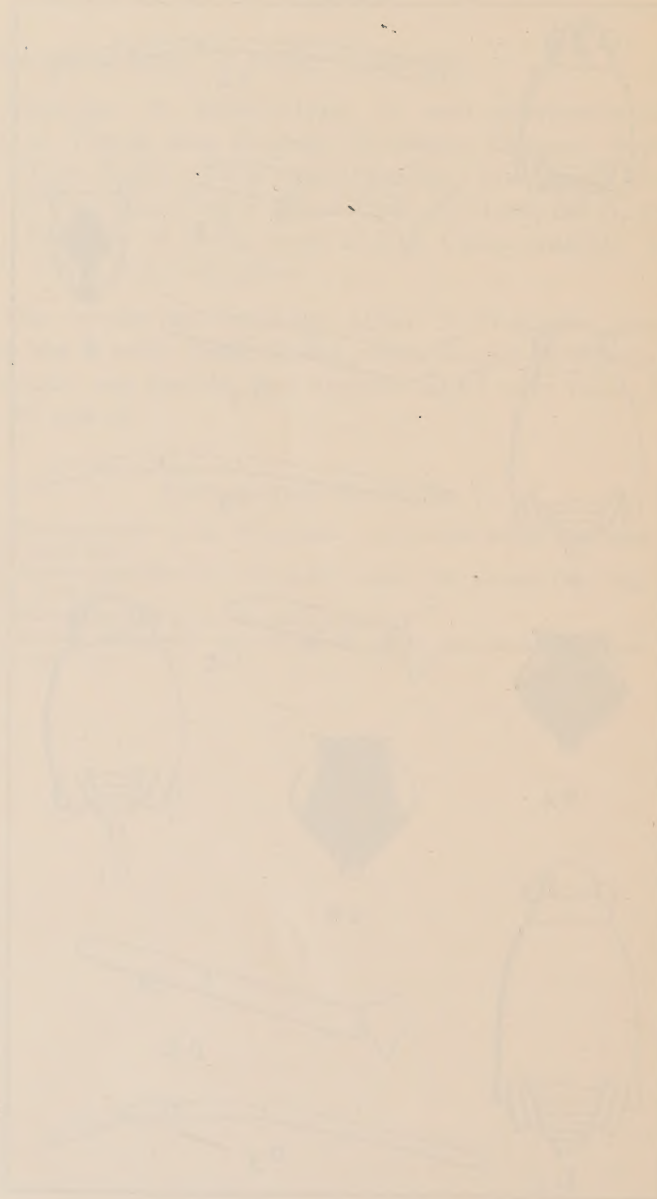
B1, *Halobates japonicus* n. sp. B2, anterior tarsus. B3, antenna. B4, Male genital segments, dorsal view.

C1, *Halobates shiranui* n. sp. C2, anterior tarsus.

D1, *Halobates matsumurai* n. sp. D2, anterior tarsus. D3, antenna. D4, male genital segments, dorsal view.



ESAKI—Halobates



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